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Vulcan Lessons

ON this page of our issue of January 4 we commented on the preliminary statements concerning the result of the R.A.F. Court of Inquiry on the Vulcan accident at London Airport last October. We said then that we were left with the unhappy conclusion that the accident had not in fact been explained at all. The following week we were prompted to draw from that earlier statement some simple mathematical conclusions, which lent support to our belief.

As officially promised, the report on the second investigation, by Dr. A. G. Touch, was published on January 24, and summarized in *Flight* last week. This week we report the inquest on the four men who lost their lives. From statements made on these two occasions we are again forced to the conclusion that the exact details are not to be found in present explanations. We cannot easily, for example, reconcile the statements by both the pilots, the G.C.A. controller and his tracker, to the effect that there was no sudden descent before the first impact with the ground, with Dr. Touch's conclusion that such a descent did in fact occur.

The question arises whether someone should not have told the crew about the poor visibility on the approach, which was worse than that on the airfield. Someone should be qualified to give such information to a captain and have both the power and the means to do so quickly. This is a problem which must be solved urgently if cases of a comparable kind are to be avoided. The Vulcan's altimeter error, we feel, had only a secondary influence in this case; and the error additional to the Vulcan's normal position-error for the approach configuration was probably caused by ground effect.

Finally, we must take cognizance of the statement in Dr. Touch's report that something in the controller-tracker-pilot-G.C.A. "servo loop" failed. The only constructive answer to this is to adopt equipment which reduces the number of people involved in this loop and reduces thereby the inherent time delays and number of possibilities of human error. Such equipment has long been available in the form of G.C.A. in which the controller directly monitors both azimuth and elevation displays. We must, however, look even further forward to an aid which will offer the pilot at least a semi-pictorial director instrument giving complete approach guidance, the only function of the ground personnel then being to monitor the approach and intervene if the aircraft goes badly astray. Autopilot coupling, with which the Vulcan is very probably intended to be fitted, can also go a long way toward achieving accuracy without undue mental stress.

At present, there is nothing in production which will positively enable a pilot, if he cannot see the ground, to correct any kind of mistake in the final and critical phases of an instrument approach. There must be someone on the ground to tell him plainly to avoid such poor visibility conditions, either by waiting for a weather clearance or by diverting forthwith.

Supersonic Old Ladies

"NOW then, young man," an old lady passenger is once supposed to have said to an airline captain, "no going faster than sound—I want to talk." She was not, of course, to know that she represented the hypothetical old lady who has become the ultimate design-case in the development of commercial aeroplanes, and that when the time comes for her really to fly faster than sound she will be able to do so in perfect safety and comfort.

When will the time come? Projection of the curve of air transport speeds over the past thirty years suggests that we may expect commercial supersonics by 1970. But, as we show on pages 175-177, the technical difficulties to be overcome appear to be of such gravity that the British Industry may capture the market only by a co-ordination of effort backed by the full resources of the nation. The Government-sponsored "exploratory" supersonic coalition, announced two weeks ago, is imaginative and welcome, and we wish its deliberations success.

As a postscript, we record our surprise that this team lacks representation by the A.R.B., and by the only two British firms with truly supersonic experience—Fairey and English Electric.

FROM ALL QUARTERS

U.S. Missiles for Britain?

IN the statement issued after the Washington talks last week between Mr. Duncan Sandys, the Minister of Defence, and Mr. Charles Wilson, U.S. Defense Secretary, the "possible adoption" by Britain of "certain American weapons" was mentioned; and it was said that this matter was being referred to the two Governments "for further consideration."

So far, no details of the type of weapons involved have been given officially, though there has been much speculation. Mr. Sandys was to be asked to make a statement in the House of Commons this week on his talks with the U.S. and Canadian Governments on defence policy.

N.A.39

CONFIRMATION of the character of this most important machine (*Flight*, January 25 and February 1) is now officially forthcoming. It is a strike aircraft being developed for the Royal Navy by Blackburn and General Aircraft at Brough. As we remarked last week, it was doubtless of the N.A.39 that the firm's chairman, Mr. Eric Turner, spoke when he said that Blackburn were working on "an important and challenging contract . . . which might eventually go into widespread service at home and abroad." His company is known to have been developing integral construction and high-lift devices for lowering landing speeds.

Indian Canberra Contract

AN Indian Government contract for 68 Canberras for the Indian Air Force, costing over £20m including spares, was signed with the English Electric Co., Ltd., last week after protracted negotiations. The order, which is for 54 Mk 8 bombers, six Mk 4 trainers and eight Mk 7 reconnaissance aircraft, with their equipment and spares, forms the largest yet placed for British military aircraft by any country outside NATO.

The decision to equip the Indian Air Force with Canberras, in preference to Russian Il-28s, was reached "in principle" last April. The aircraft ordered are to be built at the Preston, Lancs, factory of English Electric and when deliveries begin this spring or summer some of the aircraft will be flown to India by I.A.F. pilots already taking Canberra courses with the R.A.F.

Indian ground staff are to receive training at the English Electric technical school at Samlesbury, near Preston, and with Rolls-Royce, Ltd., the makers of the Avon engines.

Following recent Canberra and P.1 orders, English Electric has transferred a Ministry of Supply contract for Canberra Mk 9s to Short Brothers and Harland, Ltd., Belfast.

Non-Territorial R.Aux.A.F.?

ALTHOUGH the Air Minister, Mr. George Ward, said in Parliament on January 30 that he could not offer the disbanded R.Aux.A.F. squadrons "any hope of reprieve," ideas for their continuance on a different basis were being discussed last week-end. One proposal likely to be put before the Air Ministry was that the squadrons, now limited by Act of Parliament to a territorial basis, should be re-formed without any such attachment. Questionnaires circulated to members of several squadrons, asking whether they would be willing to re-engage for service abroad in emergencies, have apparently brought replies unanimously in favour.

The Air Minister said in his statement that it had been possible to offer many officers and men of the R.Aux.A.F. opportunities of further service on the ground, either in the 20 fighter control units which were being retained or in reserve flights at R.A.F. stations near their homes.

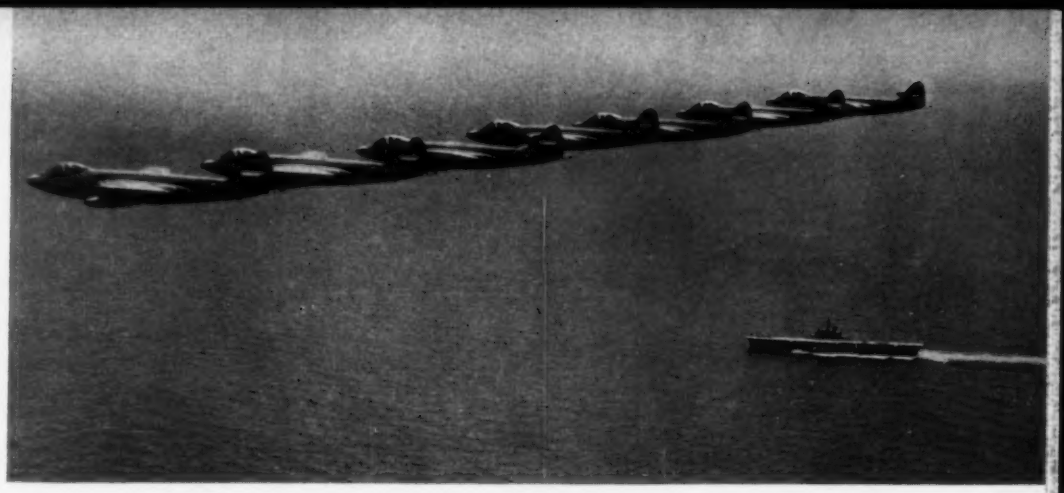
On January 31 the Parliamentary Secretary to the Admiralty, Mr. Christopher Soames, stated in answer to a question that the Admiralty was "unable to reconsider" its decision to disband the Air Branch of the R.N.V.R.

FIRST DEPARTURE: Sir George Cribbett, B.O.A.C. deputy chairman, wishes Godspeed to the passengers boarding G-ANBI for B.O.A.C.'s first scheduled Britannia service. On his right are Sir Reginald Verdon Smith, chairman of the Bristol Aeroplane Company, Mr. Airey Neave, Joint Parliamentary Secretary to the M.T.C.A., and Mr. James Jefts, L.A.P. commandant. Further details appear on page 191.

Hawker Redundancy

AS a result of the Government decision to cancel orders for 100 Hunters, Hawker Aircraft, Ltd., have decided to withdraw Hunter production from their factories at Blackpool and Langley, and concentrate it at Kingston-on-Thames. The dismissal by the summer of 700 men now employed at Langley—near Slough—was announced on January 23; on January 29 the company issued a statement about their Blackpool factory; and Mr. J. T. Lidbury,

LUFTWAFFE INSIGNIA give an oddly foreign look to a truly British aircraft—a de Havilland Heron. The first machine to be delivered from Britain to the German Air Force, it is arranged as an eight-seat executive for Gen. Kammhüber, Chief of Air Staff, and was recently flown out to Wahn. A second Luftwaffe Heron will be delivered later this year.



SHIPS OF THE LINE: Only lately released by the Admiralty, though taken about a year ago, this official photograph shows a faultless echelon by Hawker (Armstrong Whitworth) Sea Hawks of No. 811 Squadron, H.M.S. "Centaur." The carrier visible in the picture is H.M.S. "Albion."

director and general manager of Hawker (Blackpool), Ltd., told employees that unless the Government could place a major project at Blackpool almost immediately the factory would have to be run down.

In the company statement, which described the Squires Gate premises as "the biggest single aircraft production unit in Europe, employing nearly 4,000 people," it was said that withdrawal of work to Kingston would result in "heavy progressive redundancy" at Blackpool, beginning almost at once and building up over the next few months.

Questioned in the House of Commons about redundancy in the aircraft industry following defence cuts, the Minister of Labour said he recognized that the position had deteriorated recently and he was watching it carefully. An all-party deputation from Blackpool Town Council has been formed to meet the Minister of Supply for discussions on how to avert redundancy at Squires Gate.

The Swedish Government order for 96 Hunters, of which about 74 have been built, is to be completed at Blackpool.

The Gloster Aircraft Co., Ltd., are to dismiss 700 employees by June this year—not 1,300 as originally estimated—because no further orders for the Javelin have been received.

New American Missiles

PROBABLY no other field of endeavour is developing more rapidly than that which includes guided weapons, automatic control, research test vehicles and kindred devices. Several American developments have been cleared from "security" during the past week, and the following notes can be regarded as a supplement to the special missile issue published by us on December 7 last.

One of the oldest American weapon programmes still active is that for the Rascal, by the Bell Aircraft Corporation, of Buffalo. Originally styled pilotless bomber XB-63, it is now designated GAM-63, or guided air missile. It consists essentially of a simple Mach 1.5 airframe driven by a Bell triple-barrel (aluminium-alloy chambers) rocket, and filled with propellants, inertial and star-tracking guidance and a nuclear warhead. A picture (p. 177) shows the forward control surfaces and rear wings and trimmers, all of which are double-wedge sections of trapezoidal plan-form. The fuselage is fat for a supersonic vehicle.

Rascal has been launched from B-47s since 1953 and is now in full Strategic Air Command service with that aircraft and the B-36 and 52. Range is up to 100 miles and reliability and general behaviour are good. This is to be expected from a weapon whose roots go right back to the original Bell X-1.

Also shown on page 177 is a fearsome-looking aircraft-like vehicle designated X-10 which North American Aviation built in 1952-3 to gather data for Navaho. The latter is now emerging as a 100,000ft-cruise, Mach-4, intercontinental bombardment weapon driven by two 48in ramjets. The X-10 was less ambitious and in its original form, as shown, was powered by nothing better than a pair of afterburning Westinghouse J40 turbojets.

Curious features include the 60-deg delta foreplane and rear-mounted wing, the kinked vee-tail surfaces with enlarged root sections and the unexpected post (probably an aerial) above the fuselage.

Even X-10 could reach well above 55,000ft and so the engine intakes were inclined downwards from the fuselage axis in order to recover maximum pressure at high angles of attack. Some 25 of these airframes were flown from Edwards A.F.B. and the Missile Test Center at Patrick A.F.B. since 1954. Most were successfully recovered for re-use, since a conventional undercarriage and brake 'chute were fitted for this purpose. Suffice to say that the true SM-64 Navaho bears little resemblance to X-10.

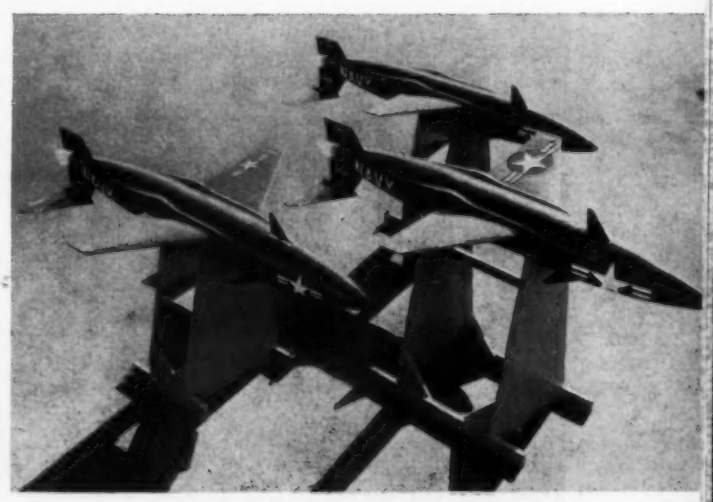
Fulfilling a similar function (data gathering), but for a more advanced weapon, is the Lockheed X-17. One of the first major products of Lockheed's Missile Systems Division, the X-17 is a three-stage, 12,000-lb research vehicle designed to reach to more than 300 miles' altitude. The third stage is a blunt-nosed assembly which simulates the warhead of an intercontinental ballistic missile on its re-entry to the atmosphere. Several X-17s have been successfully fired from Patrick A.F.B.

Quite unlike the foregoing in technical character is Martin's Lacrosse (sometimes spelt La Crosse), a tactical weapon now being delivered in test-quantity to the U.S. Army. Developed by the Cornell Aeronautical Laboratory, Lacrosse has a solid rocket motor and can be fired in any weather from the vehicle illustrated. The all-weather capability is unusual in front-line missiles, and Lacrosse has demonstrated its ability to hit armoured vehicles, strong points and the like with uncommon precision. Further details were published in our December 7 issue.

Italians at Paris

IN the news again are two projects by the Italian Agusta company of Cascina Costa, Gallarate—projects of which very little has been heard since the 1955 Paris Show. The two machines are a large (14-passenger) helicopter and the Agusta-Zappata AZ-8L—a 22/26-passenger low-wing monoplane feeder-liner, powered alternatively by four Alvis Leonides or four S.N.E.C.M.A. 12S inverted vee-twelve air-cooled engines. Maximum weight and cruising speed were given respectively as 23,810 lb and 252 m.p.h. Neither of these machines has yet flown, but now it is reported that "every effort" is being made to have them ready for the Paris Show (May 24-June 2).

The Agusta company has now completed the first Bell 47J helicopter made under licence. It will almost certainly be in the show.



ON TEST by the U.S. Navy at Point Mugu, Cal, is the Radioplane XKD4R-1 drone, powered by a rocket motor with nozzles at the wing trailing-edges. The whole rear end houses guidance and controls, and tracking and scoring gear fills the nose. The airframe, of moulded plastic, is small enough to be carried by a fighter.

The Wing marches past A-Able for the last time.

FAREWELL to the FLYING-BOAT

—in the home-based R.A.F.: Nos. 201 and 230 Squadrons Disbanded at Pembroke Dock

ILLUSTRATED MAINLY WITH "FLIGHT" PHOTOGRAPHS

AT Pembroke Dock on Thursday of last week the Royal Air Force in Great Britain said farewell to its last Sunderlands. From now onwards only the unit operating with Far East Air Force will have flying-boats and no replacements are in either the design stage or contemplated.

This sad occasion marked not only the demise of the military flying-boat in Britain but also the disbandment of two fine squadrons, Nos. 201 and 230. What will happen to the Pembroke Dock base is not known; building extensions are still in progress but (as a Service cynic remarked) that could easily be the left hand of Works not knowing what the right hand of Operations doeth.

If present arrangements stand, three reconditioned Sunderlands will be flown out to the Far East and the remainder of the squadron aircraft to Wig Bay in Scotland, for overhaul and storage.

The prototype Sunderland was developed from the Short Empire boat and was first flown by John Lankester Parker (then chief test pilot and now a director of Short and Harland) in 1937. The type was in service with the R.A.F. within a year of the first machine flying (a remarkable achievement even in those days) and No. 230 Squadron was the first unit to be equipped.

The Sunderland had a wonderful war record with Coastal Command, mostly on anti-submarine and reconnaissance patrols far out into the Atlantic and Indian Oceans. On these long-range vigils the aircraft were airborne for up to 14 hours but there were occasional instances when, by jettisoning bombs and depth-charges, endurance was increased to over 18 hours, and in one case to 22.

With its front, rear and dorsal turrets the Sunderland was well able to look after itself, and the Germans (who sometimes called it "the Porcupine") had a healthy respect for it.

Lankester Parker, who was present at last week's disbandment ceremony, had an interesting recollection of the effect of fitting the heavy, power-operated turret in the tail. When it was first installed in the prototype it was found necessary to give compensating sweep-back to the wings. This meant that the wing-tip floats pointed outward by the amount of the sweep-back; and they still do. Another noteworthy feature of the Sunderland—in comparison with most other long-service aircraft, in which power usually has greatly increased with development—is that whereas it started in service with Bristol Pegasus engines, each of about 1,050 h.p., and an all-up weight of 44,600 lb, it now has Pratt and Whitney engines giving little more than 100 extra h.p. each; yet the all-up weight is now 65,000 lb.

The Sunderland was produced in four versions, Marks 1, 2, 3 and 5, and when the last of them came off the production line in October 1945, 721 had been built.

Apart from those remaining in service in the Far East they are still on active duty with the Royal New Zealand Air Force and a squadron of Mk 5s are at present being re-conditioned for the French Naval Air Service.

For the farewell to the two Pembroke Dock squadrons a ceremonial disbandment parade was held, at which the reviewing officer was the A.O.C-in-C. Coastal Command, Air Marshal Sir Bryan V. Reynolds. Among the many Service guests present

A-Able, clean, smart but forlorn, alone in its hangar at Pembroke Dock awaiting a crew to fly it to the Far East. It has been the craft of F/L. C. A. Nicoll and was at the Tower of London for Battle of Britain week.

(Above) One of the earliest Sunderlands, a Mk I (Bristol Pegasus engines).

(Left) John Lankester Parker, who as Short's chief test pilot flew the prototype Sunderland, watching the disbandment parade.

(Right) Air Marshal Sir Bryan Reynolds, A.O.C.-in-C. Coastal Command, inspects some of the aircrew of No. 230 Sqn.

were Air Marshal Sir Alick C. Stevens; a former (1951-53) A.O.C-in-C. Coastal Command; A.V-M. G. I. L. Saye, A.O.C. No. 19 Group; and A.V-M. P. L. Cracroft, A.O.C. No. 18 Group. Commanding the Wing parade was W/C. J. M. Helme, and each of the squadrons was in the charge of its commanding officers: S/L. D. Baird (No. 201) and S/L. P. Adams (No. 230).

After the inspection Sir Bryan addressed the parade. Of the disbandment he said: "I want you all to know that I, most of my staff at Coastal Command Headquarters, and I am sure those at Air Ministry are rather sad today, for two reasons: firstly because of the era of the flying-boat ending here today in the United Kingdom, and secondly because the number-plates of two of the oldest squadrons of Coastal Command, Nos. 201 and 230, are to be 'hung up.'

"My staff have been working on ways to retain the numbers of your squadrons, but so far have not found other operational units suitable to be called No. 201 or No. 230 squadrons. However, as you know from the histories of the squadrons, they are from time to time disbanded and re-established sometime later. We shall see that when numbers are re-allocated they are given to units worthy of such renowned squadron titles."

Picture gallery in A-Able's galley: Left, Flt. Sub-Lt. Warneford, V.C.; centre, Major Barker, V.C.; right, the Queen with A.V-M. G. W. Tuttle during her visit to Pembroke in 1955; and the same Sunderland on the water in Milford Haven.

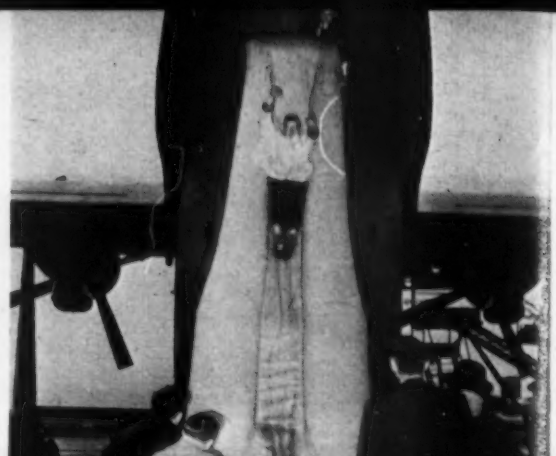
The A.O.C-in-C. ended by giving some extracts from the squadrons' histories.

No. 201 Squadron was, of course, derived from the original No. 1 Squadron, Royal Naval Air Service, which, in common with other Naval air units, had 200 added to its number when transferred to the Royal Air Force in 1918. This was done to avoid confusion with squadrons of the same number belonging to the Royal Flying Corps. In the First World War the squadron won two Victoria Crosses—by Flt. Sub-Lt. Warneford and Major Barker—and had a wonderful active service record in World War 2. It was disbanded from 1919 to 1929. A history of the squadron appeared in *Flight* for April 11 and April 18, 1952. By a curious chain of circumstances No. 230 became the stepfather of No. 201. In 1922 No. 230 moved with its F.5 boats from Felixstowe to Calshot and amalgamated with the Naval Co-operation Flight stationed there. Later this combined unit became No. 480 Flight and later again changed to No. 201.

No. 230, in the 1914-18 war, served from 1917 as the Flying Boat War Flight, getting its squadron number in 1918. After the amalgamation recorded above No. 230 remained disbanded until, equipped with Short Singapore 3 flying-boats, it was re-formed at Pembroke Dock in 1934. Nearly the whole of its war life was spent in the Middle and Far East. The highlights of its more recent peace-time career were the part it took in the Berlin Air Lift in 1948 and the ferrying of supplies and personnel for the British North Greenland Expedition in 1952 and 1954.

At last week's parade it had been intended to fly one Sunderland for the last time and to have the crews standing on the wings of their aircraft while the A.O.C-in-C. took the salute from a launch. Unfortunately, even the weather at Pembroke Dock was in tearful mood; the rain teemed down and the wind gusted up to 70 kt. But not to be entirely defeated, the two squadrons marched out of the hangar in which the parade had been held, crossed the rainswept apron, and paid a last tribute to the Sunderlands by passing in front of 201s A-Able parked by an open hangar door.

The parade dismissed at the double; and our last sight of the last marine aircraft of the R.A.F. in Britain was a line of Sunderlands—still, after 21 years, looking curiously modern—riding at their buoys and obscured every now and then by flurries of wind and rain. A great and heroic epoch was ended.



BACKSLIDING: Trials have recently been made of a fabric escape-chute designed to facilitate emergency ground-exit from the parachute door of the Blackburn Beverley. The door is 19ft from the ground, and a damaged nosewheel could increase this distance to 24ft. Contained in a valise, the 30ft chute can be quickly anchored to the floor near the exit and inflated to a trough shape by CO_2 bottles in 15 sec.

HERE AND THERE

Hustling Heavyweight

FIRST cross-country flight by a Douglas C-133 logistic transport, powered with four Pratt and Whitney T34 Turboprops, was made recently from Long Beach, Calif., to Dayton, Ohio. This distance of 1,900 miles was covered in 5 hr 45 min at an average speed of approximately 350 m.p.h.

Bristol Proposal

A REQUEST by Bristol Aircraft, Ltd., to build Sycamore helicopters at the Government Aircraft Factory, Fishermen's Bend, Melbourne, is being considered by the Australian Department of Defence Production.

S.A.C. Lecture

A SENIOR officer of the U.S.A.F. is to address an Air-Britain meeting in Caxton Hall, London, S.W.1, at 7 p.m. next Wednesday, February 13. His subject will be the U.S.A.F. Strategic Air Command.

Timeo Danaos . . .

AN Il-14, gift of the Soviet Government to President Sukarno of Indonesia, was recently delivered by a Russian crew to Djakarta airport for the official handing-over ceremony.

Solo Fright

AT Des Moines, Iowa, on January 29 a 22-year-old clerk, Roy Soderquist, commandeered a single-engined aircraft at pistol point after a flying lesson. He then flew back and forth at low altitudes over the town, bringing everything to a standstill, before crash-landing without seriously hurting himself.

W.J.A.C. at Oxford

A UNIT of the Women's Junior Air Corps has been formed at Oxford.

Ex-R.A.F. Pilots Recalled

AMONG the Polish Air Force officers recalled to duty after being dismissed during the "Stalin period" are S/L. Ignacy Olszewski and S/L. Waclaw Krol, both of whom commanded Polish fighter squadrons in the R.A.F. during the war.

Whirlwind for Yugoslavia

AN order for a Whirlwind helicopter has been placed with Westland Aircraft, Ltd., by the Yugoslav Government. It is the first to be placed by any Balkan country for this type. In addition spares have been ordered for the ten Westland Dragonflies operated by the Yugoslav military forces.

Aerodrome Adoption

A PLAN for schools to "adopt" aerodromes within the Commonwealth, on similar lines to the present adoption of Merchant Navy ships by 900 schools, is being sponsored by the Air League of the British Empire in co-operation with the Ministry of Education. A "pilot" scheme is to be run this year, with 24 selected schools taking part, and if it proves successful an aerodrome adoption society will be formed.

Private View

HELICOPTERS are being employed at Alesund, centre of the Norwegian herring fisheries, for rescue duties and to give tourists an opportunity of seeing the fleet of some 2,500 boats at work among the shoals.

Synthetic Rubber Symposium

AN international symposium on synthetic rubber is to be held at Church House, Westminster, from March 26 to 28. Application forms may be obtained from the organizers, *The Rubber and Plastics Age*, Gaywood House, Great Peter Street, London, S.W.1.

Spares by Air

DURING 1956 the Automobile Association despatched over 700 sets of spare parts by air to motorists and motor-cyclists touring abroad. The highest number of deliveries, 378, was made to A.A. members in France; other destinations to which spares were flown included Poland, Finland, Southern Rhodesia and West Africa.

Accident Inquiry Procedure

IN answer to recent Parliamentary questions asking for a statement on changes in the procedure of aircraft accident inquiries when both Service and civilian departments were concerned, the Prime Minister said that as several "complex and difficult points" were involved it would be some time before a statement could be made.

Beech Distributors

A COMPANY registered in Ireland—Aircraft Associates, Ltd. (formerly Irish Sales and Commodities Co., Ltd.)—have been appointed distributors for that country and for the U.K. by Beech Aircraft Corporation of Wichita, Kansas. The current basic prices of Beechcraft models are: Super 18, Model E185, $106,975; Twin Bonanza, Model E50, $88,000; Twin Bonanza, Model D50, $77,000; Travel Air, Model 95 (Twin), to be announced; Bonanza, Model H35, $22,650. A demonstration Bonanza is now at Liverpool Airport.

JOS, in Northern Nigeria, was the objective of a recent solo flight from Elstree by Tiger Moth owner Peter Jordan, a tin-mining engineer. Mr. Jordan started learning to fly in June, 1956, obtained his P.P.L. in July, and then purchased G-ANZY for £350. A total of 47 stops were made on the 5,500-mile journey, which was completed in 33 days, using some 350 gal of petrol.

DESIGN FOR PRODUCTION

An Important Paper by the Chief Designer of Armstrong Whitworth Aircraft

CURIOUSLY, there have been very few published papers on the specific subject of the actual design, planning, scheduling and general domestic programming of a new aircraft design. All the more valuable, therefore, is an exceedingly thorough assessment of the subject by Mr. E. D. Keen, B.Sc., F.R.Ae.S., A.F.I.A.S., chief designer of Sir W. G. Armstrong Whitworth Aircraft, Ltd. In this and the following pages we summarize Mr. Keen's paper, which was presented as a section lecture to the Royal Aeronautical Society on January 29.

The title of the paper [said the lecturer in his introduction] implies that, in general, aircraft design is not fundamentally suitable for production and of course, for various reasons, design for quick and easy production must be the result of compromise. In practice optimum design and easy production never seem to coincide exactly. Refinement of design for production covers many broad conceptions.

In its narrowest sense the revision of detail design to allow fabrication by more economical methods of production offers a wide scope for economies in time and cost, and in between these two extreme interpretations of the title of the paper pros and cons of various basic types of construction offer fruitful fields for discussion.

The foundation on which the grand plan for instituting a production run is based must be the promised dates by which the drawings will be issued. By reference to records of previous aircraft with suitable adjustments for size factor, complication factor, operational rôle, etc., estimates must be made of target dates for the issue of sufficient drawings to produce the first prototype. The author's firm is now using the Hollerith system of recording and analysing D.O. records. In Fig. 1 the horizontal lines give the period over which drawings will be issued, the left-hand ends giving the dates of issue of the first drawing and the right hand ends the dates on which sufficient drawings are available to build the first prototype component. The top two lines also have marked on them the percentage of the total number of drawings to be issued by the given dates so that by use of a normal type of progress sheet the actual achievements can be continuously compared with the estimates.

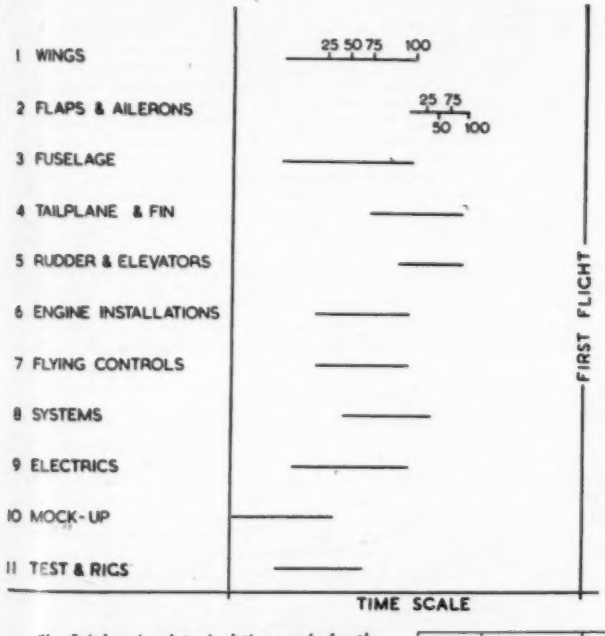


Fig. 1 (above). A typical time-scale for the issue of drawings for a first prototype. The diagram is explained at the top of column 2 on this page.

Correct phasing of these components is essential if valuable time is not to be wasted. There has been too much of a tendency in the past to tackle the apparently easy things first. Thus, tailplanes, fin, rudder, elevators, flaps and ailerons, because of their relative simplicity have been drawn out and issued as quickly as possible, thus apparently impressing the production departments with how quickly the design office is getting on with the job. How much better to start on the difficult production tasks first; the large components which require more complicated jigs and tools, more floor space and, what is far more important, contain more equipment, always the bottle-neck in any aircraft production line. Thus, in the author's view, the smaller components should be left until later when there is less likelihood of alteration and to allow a proper emphasis by the production departments on the difficult components first. Meanwhile the production departments have been working on similar lines and have produced an estimated aircraft delivery programme (Fig. 2.)

Each part or assembly is given a priority to indicate its position in the fabrication cycle. The priority of any part is determined by its proximity or remoteness to the completed aircraft. Normally this is the next lower priority to the assembly in which it is fitted, but in the case of parts with an exceptionally long "make" cycle time, i.e., longer than 10 weeks, a still lower priority number may be allocated. Although the early priorities (1 and 2) are mainly machine shop and press shop parts, and main assemblies carry the later priorities (4, 5 and 6), there are many small parts which have later priorities if they are needed at a later stage of assembly. Each part or assembly has one priority only, although it may be used at two or more stages in fabrication. In these cases the priority is determined by the earliest requirement.

The days when the sole object of the workshop organization was to concentrate manufacture on those parts required for the first prototype in order to get a shiny new aircraft which will just about fly on the earliest possible date (and then claim a new record) are now fortunately disappearing. Manufacturers as a whole and production teams in particular are beginning to realize that a prototype aircraft without a pressure-sealed structure or air-conditioning equipment, restricted in its speed range by non-completion of structural or resonance tests and the like, is more of a liability than an asset. Further, this contraption then goes to the S.B.A.C. Show where it obviously doesn't fly as fast as it should and because of its early appearance emphasizes in the public mind the very long time between this and the time when production aircraft are in service. Large structural test specimens now amount to two additional (unequipped) aircraft and the production depart-

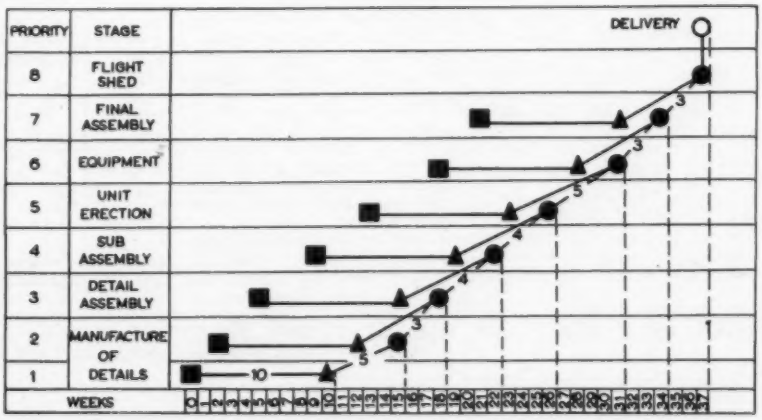


Fig. 2. A typical programme of manufacturing priorities, indicating the flow of details and sub-assemblies to the first-flight stage. The rectangles indicate start of detail manufacture and the triangles completion thereof; the circles locate the completion of stage assembly.

DESIGN FOR PRODUCTION . . .

ments must be prepared to allocate these extra components very early in the programme if the full benefit is to be obtained from the prototype aircraft (Fig. 3).

Mention has already been made [continued the lecturer] of the necessity of completing structural test specimens before flight and of the early completion of tunnel tests before the construction of control surfaces. There are many other facets to the successful initiation of a fully approved production programme and the whole picture from initial design to final product is illustrated in Fig. 4. This can be used as a master progress chart to assess achievement against targets, and highlights the necessity for making special efforts to correct any items which may become out of phase. Each item should have its own separate planning chart for this purpose. The diagram illustrates many important principles if the project is to be successful:—

(a) Wind tunnel tests should be completed as soon as possible so that stabilizers, control surfaces, etc., may be finalized in time to avoid changes in the shops.

(b) Mechanical tests on detail parts should also receive top priority in design and manufacture, for the same reasons.

(c) Maximum engineering development on all "systems" should be completed on ground rigs before these items are installed in the aircraft.

(d) The static airframe tests should be completed before the flight of the first prototype to avoid strength restrictions on flight manœuvres or pressurization.

(e) Stiffness and resonance tests should be completed and assessed before the flight of the first prototype to avoid speed restrictions.

(f) Fatigue tests, both detail and airframe, should be completed by the commencement of the production programme.

(g) Flight tests including winterization and tropical trials should be completed before the production run starts.

(h) C.A. release, or C. of A. should be obtained before delivery of first production aircraft.

There is no doubt that the quality and type of equipment, and the conditions under which they are used can have a marked influence on output in design. The British specialist team who visited the U.S.A. under the auspices of the Anglo-American Council on Productivity reported that companies had paid special attention to drawing equipment and adequate accommodation and amenities, even to the extent of experimenting with multi-colour schemes of decoration. One firm reported a "considerable" increase in output with the same staff, merely by moving to more commodious accommodation. Adequate reference space is a prerequisite for any designer aiming at productivity. The loss of valuable time by design draughtsmen trying to make do with a very limited reference table is considerable. A comfortable adjustable seat with a back and a readily adjustable drawing table with a light green backing paper, allied to a shadowless lighting system giving not less than 75 foot-candles at board level is suggested as an ideal. Drawing machines of various types to suit office preference are available, but the old Tee square has undoubtedly outlived its usefulness as a production instrument.

It is essential that the design office is fully aware of the facilities available immediately in the workshops. An enterprising production organization is constantly adding new equipment and introducing new processes which are potential improvements in production times. Copies of a manual giving details of all the "special plant" installed in the author's works are circulated to all section leaders and filed for reference in the technical library.

The type of construction necessary for a new project may be dictated by design considerations if, for instance, flight speeds are much advanced beyond current designs. Early consultation with works departments is necessary to obtain new plant and introduce new techniques. In less sophisticated regimes, such as that of current civil aircraft, alternative methods are possible and here a compromise must be made between what is essential for design and what is expedient in the works. This process can also work in reverse where the production departments claim production advantages for new methods which have to be examined for suitability by the design office.

The key to success guiding a new project through all its stages is effective liaison between production and design at all levels. Day-to-day queries from the shop floor are usually handled through the process planning department representatives, using shop query forms (with or without prior verbal consultation) with the particular design office section concerned. This scheme demands immediate and sympathetic consideration by the D.O. and depends for its success on the goodwill existing between the departments. Modern tendencies for D.O. and works to be separated makes this more difficult and intrinsically demands a higher standard of accuracy and clarity on initial drawings if irritating delays are not to occur.

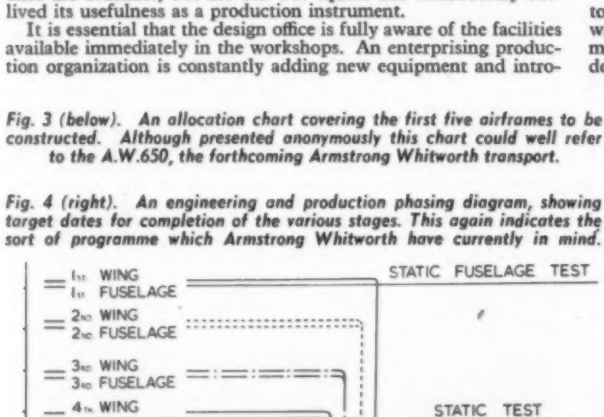
Production advisers are usually people with a wide experience . . . who are attached to the D.O. Their duties vary in different organizations from merely consultative to a responsibility for vetting all drawings for suitability for production. The development committee must consist of members of high executive standing with the power to make decisions on the spot or to order more detailed investigations. This committee should meet as soon as the chief designer can give any indication of the probable shape and size of the project and certainly well in advance of issue of drawings.

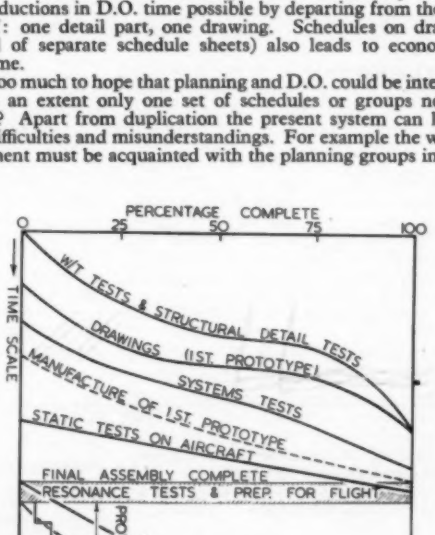
It is doubtful whether any drawing system really exists and in any case the system is often geared to the particular organization in which it is to operate, causing quite a few headaches when parts are sub-contracted. The S.B.A.C. system has, however, gone a long way to solve this problem and most firms are now using it in one form or another. Latest thoughts indicate that the lettering and numbering system should enable the location of a detail part to be recognized, i.e., the aircraft and component on which it is used. The character of drawings varies considerably and quite large reductions in D.O. time possible by departing from the principle of: one detail part, one drawing. Schedules on drawings (instead of separate schedule sheets) also leads to economy in D.O. time.

Is it too much to hope that planning and D.O. could be integrated to such an extent only one set of schedules or groups need be written? Apart from duplication the present system can lead to many difficulties and misunderstandings. For example the weights department must be acquainted with the planning groups in order

Fig. 3 (below). An allocation chart covering the first five airframes to be constructed. Although presented anonymously this chart could well refer to the A.W.650, the forthcoming Armstrong Whitworth transport.

Fig. 4 (right). An engineering and production phasing diagram, showing target dates for completion of the various stages. This again indicates the sort of programme which Armstrong Whitworth have currently in mind.





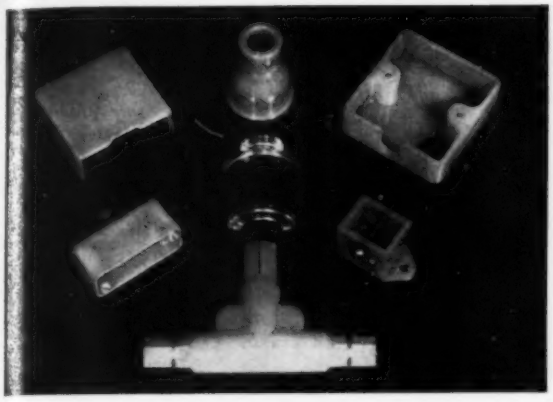


Fig. 5 (left). Parts moulded in nylon or polystyrene. This process has proved invaluable for aircraft and missile electrical details.

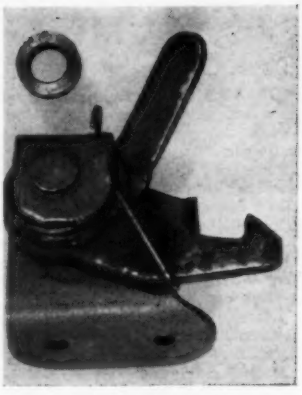
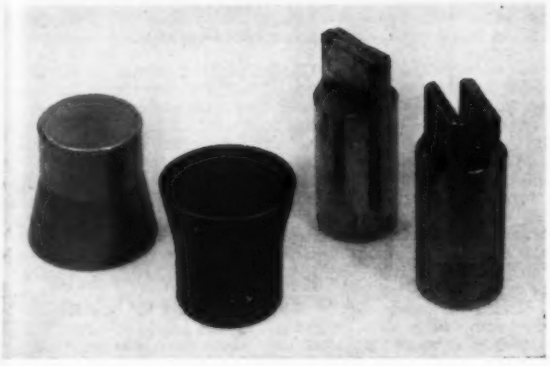


Fig. 6 (below, left). Impact extrusions; these parts would otherwise have been machined from bar.

Fig. 7 (right). An investment-cast catch of a type formerly welded from machined parts.



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to understand the weights supplied by the shops. Since target weights have been estimated from design grouping this leads to a considerable amount of difficulty. Finally, a numbering system incorporating the fewest possible letters and digits results in a significant saving in clerical time when it is realized that one part number is likely to appear on design, planning, ordering, manufacturing and inspection documents totalling at least 50 per part number (ignoring copies) and that something like 20,000 differently designed parts are needed to make an aeroplane.

In general the smaller the unit size the better, giving reduction of "in-jig" times. This may demand the use of joints which might not otherwise have been necessary and design penalties from weight and fatigue must be carefully watched. The S.B.A.C. has issued an excellent pamphlet entitled *The Financial Aspect of Weight Saving* which is of great value in deciding just how far the D.O. can meet the shops.

One of the fundamental requirements for efficient production is that the operation cycle times should be as short as possible. The shorter the cycle time the more efficient the operator(s) can become and similarly the organization surrounding the operator becomes more efficient. In general, the higher the production rate, the greater the amount of sub-assembly is required. Ideally, cycle times and jig times should be whole fractions of the shift time; unfinished cycles at the end of a working day are highly inconvenient and particularly embarrassing in double-shift working. It can be shown that in order to achieve a production cycle of one per week either two main jigs and four (much smaller) sub-assembly jigs can be used instead of six much more complicated jigs to build up the structure complete. The latter method has several disadvantages which all add up to higher production costs.

Great advantages accrue from arranging joints in systems, controls, etc., to correspond with unit sizes, enabling each unit to be completed, equipped and tested before the final assembly stage. Finally, unit sizes have to be carefully watched, not only from the point of view of major repairs but they often have to be transported from one factory to another.

This thorny subject probably represents one of the most serious areas of conflict between the prime necessity of saving weight and ease of production. There can be no doubt that wider tolerances reduce costs of production whether it be in the machine shop or rolling mill. There can be no relenting here from the D.O. point of view and the shops must be urged to do the best they possibly can to keep to nominal sizes. The problem is very largely one of psychology and, recognizing this, much thought has been given to statistical methods of strength assessment whereby the general shop performance is used instead of the most adverse drawing tolerances.

Consider a non-fitting part on which the shops usually demand ±0.010in. As the regulations stand at the moment it is mandatory to stress this part to −0.010in on an outside diameter, whereas in the majority of cases the shops produce the part to +0.010in. Assuming an average ruling dimension of 1in this represents an excess of weight of 4½ per cent. Taking this as a basis and assuming that there are 5 per cent of such parts in the structure weight of an aeroplane a weight penalty of 0.2 per cent ensues or 0.07 per cent increase in take-off weight. Alternatively, this could result in a 0.2 per cent reduction in payload of a medium-size civil aircraft reducing it by 50 lb in 25,000 lb, causing an annual loss in revenue of £2,500.

At this point Mr. Keen turned his attention to a brief discussion of four advanced methods of parts-forming in which finished forms were produced with a minimum of machining. He also commented on the advantages which accrued from the handing of parts; i.e., from making port and starboard units interchangeable.

A wing-tip made by Armstrong Whitworth was originally welded from two drop-hammered halves; later it was stretched on a Hufford machine, with savings in cost and time, and with better pre-assembly properties. Fig. 5 showed some moulded plastic (nylon and polystyrene) parts, which would otherwise have been machined from solid. Fig. 6 depicted examples of impact extrusions, which were cheaper than fabricated or machined parts and also had better grain flow. Fig. 7 was an example of investment casting, the subject being a catch formed from close-tolerance castings requiring no machining.

In conclusion, Mr. Keen re-emphasized his belief that early and co-operative planning was essential. For final success, a spirit of mutual co-operation had to pervade the whole organization.

ALTIMETER-STANDARD REVISION

A REVISED British Standard for sensitive altimeters (B.S. 2G 115:1956) has been issued, principally on account of the introduction of the I.C.A.O. "Standard Atmosphere," which supersedes the I.C.A.N. relationship between static pressure and height, to which these instruments were formerly calibrated.

This standard is applicable to mechanical instruments operated directly by an aneroid barometer movement. The performance requirements are based on two ranges, −1,000ft to 35,000ft and −1,000ft to 50,000ft respectively. The tabulated pressure-height tables have been revised and barometric data are quoted in accordance with B.S. 2520, *Barometer Conventions and Tables*.

However, because test barometers with scales to standards other than B.S. 2520 are likely to remain in use for some years, Appendix A of B.S. G 115:1949, containing instructions for the correction of barometers with inch scales related to London laboratory conditions, is retained in the present revision as Appendix B with appropriately amended pressure-height tables.

The table of fiducial temperatures for various latitudes and heights above m.s.l. has been modified as a result of changes in the formulæ for establishing gravity corrections. Comparable information for barometers in accordance with B.S.2520 is given in that specification.

Copies of 2G 115:1956, price 3s 6d, are obtainable from the British Standards Institution, Sales Branch, 2 Park Street, London, W.1.

SHORT'S TRANSPORT PROJECT

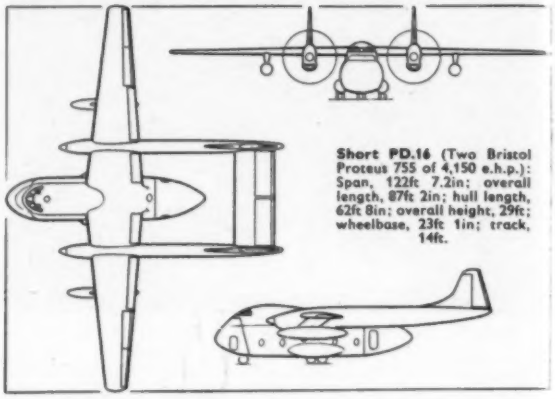
RARELY is it possible to publish details of an aircraft design, the existence of which has remained unknown to the public and which has never reached what America calls the hardware stage. For several arduous years Short and Harland at Belfast have been at work on a transport design of unusual versatility, known as the PD.16. For various reasons—quite unconnected with the relative merits of the two aircraft—the field for which the PD.16 was designed will now be filled by Armstrong Whitworth's A.W.650 series. Shorts have released the entire project-study on the PD.16, and it is a most absorbing two-inch-thick document, emphasizing the tremendous effort which went into the programme.

As the drawing shows, the PD.16 would have been a good-looker with a vast swelling fuselage of considerable cross-section. Originally the power would have come from four Rolls-Royce Darts, A.S.M. Mambas or Bristol Hercules, or a pair of Napier Elands, Rolls-Royce Tynes, Bristol Orions or Bristol Proteus. The latter might well have powered the first machine—had it been built—the installation having an Allison-like ventral air intake.

Basically of circular section, the pressurized fuselage was to have had an unobstructed floor some 40ft by 9ft 2in, with a maximum interior width of 12ft. Access to the hold, and to the flight deck above, would have been gained through an upward-hinging nose section and clam-shell doors at the rear. Special variants of the basic machine would have had a wider (two cars abreast) hold, a beaver tail (for heavy dropping), and possibly even a single rear fuselage in lieu of booms or a "pi-tail," as evidenced by earlier Chase designs. Several special military variants had been investigated.

Unlike British, but like American, aircraft in the same class the PD.16 would have had a narrow-track sponson-retracting main undercarriage. Flying controls would have been operated by manual servo-tabs, and the flaps would have been of the double-slotted type (which, incidentally, were found to present a better solution than "blown" plain flaps, because of the engine power tapped off to feed the latter). A feature of particular interest is that, like the C-119H, the PD.16 would have carried all its fuel externally, in a pair of under-wing tanks equipped as single cells with twin booster pumps. Power systems reflect a degree of Britannia influence, partly owing to the probable choice of the Proteus as the powerplant.

Typical weights for a Proteus 755 machine would have been:



Short PD.16 (Two Bristol Proteus 755 of 4,150 e.h.p.): Span, 122ft 7.2in; overall length, 87ft 2in; hull length, 62ft 8in; overall height, 29ft; wheelbase, 23ft 1in; track, 14ft.

basic equipped, about 42,000 lb; payload about 25,000 lb or 65-70 passengers; gross weight, 69,000 lb. At the latter figure the tropical (I.S.A. plus 30 deg C) sea-level field length would have been 1,300 yd (wet), the corresponding ground run being 615 yd. Normal climb at 65,000 lb would have been about 2,240ft/min at sea level, 20,000ft being reached in 12 min (34 miles) with consumption of 680 lb kerosine. At an easy-going compressor r.p.m. of 10,970 the true air-speed would have been 276 m.p.h. at 20,000ft at 62,000 lb, the corresponding specific range being 0.127 n.a.m./lb. A typical range/payload point for 12,000 lb tankage would have been 18,260 lb for 1,000 miles when flying for economy at 309/334 m.p.h. (or 19,280 lb when flying for range at 225 m.p.h.).

Taking the prime cost of the complete aircraft as £309,000 (a most competitive value) the d.o.c. curves for 3,000-hour utilization drop through £0.35 per long-ton statute mile at 700 miles stage to about £0.3 beyond 1,000 miles. On a 600-mile operation with a 70-per-cent load factor (cruising at 30,000ft for 3,000 hr p.a.) the d.o.c. would have been about 9.3 pence per c.t.m.; revenue rate to break even would have been 19.9 pence, 30 pence yielding 51 per cent profit.

HERCULEAN DEVELOPMENT

ALREADY fully described in past issues of *Flight*, the Lockheed C-130 Hercules is now being delivered at a high rate to the U.S. Air Force and will eventually be standard equipment for all medium transport wings of Tactical Air Command. The first unit to form is the 463rd Troop Carrier Wing of the 18th Air Force at Ardmore A.F.B., Oklahoma, which received its equipment last month.

A display of the remarkable capability and versatility of the C-130 was a highlight of the formal delivery ceremony of the first aircraft on December 9. Four loaded aircraft were delivered from their birthplace—the giant government plant in Marietta, which forms Lockheed's Georgia division—covering the 735 statute miles in some 170 minutes, notwithstanding a 60-kt headwind. Arriving in tight diamond formation, they peeled off in steep turns and landed with only a few seconds' separation, to be joined by a fifth aircraft which used brakes and reversible Aeroproducts propellers to come to a halt in less than eight fuselage lengths.

One of the aircraft carried a standard F-6 refuelling trailer, 46ft long and weighing 26,640 lb. Another brought a 23,000-lb trailer-mounted test stand for the Allison T56 turboprop, power-plant of the C-130, and a third machine carried a Nike missile and booster, nine of which (or 18 without boosters) can be carried. Another C-130 was flown by an Air Proving Ground Command crew on a multiple air-drop. This aircraft took off from Pope A.F.B., North Carolina, and flew roughly 1,000 miles to Ardmore where it dropped ten tons of supplies, loaded in 18 A-22 containers, within three seconds. Finally, Joe Barrett, a test pilot for Lockheed's Georgia division, lifted the first-delivery Hercules after an 800ft run, reached more than 3,000ft in a climbing turn within 60 seconds from brakes off, and then made two level passes, one at more than 300 kt and the other at approximately 130 kt with the large ramp door open.

On December 21, Carl Kotchian, general manager of the Georgia division, announced five new versions of the Hercules which are at present being developed at Marietta. The new adaptations are: the Ski-130 fitted with wheels and skis for polar operations; the KC-130 tanker; a photographic C-130; a command C-130; and the modified C-130B. Mr. Kotchian predicted that the Hercules would be in quantity production at the Marietta plant for a period of between ten and fifteen years.

FORTHCOMING EVENTS

Feb. 11. Institute of Transport: Brancker Memorial Lecture: "Competitive Economics of Pure-jet v. Turboprop Aircraft," by Marshal of the Royal Air Force Lord Douglas of Kirtleside, G.C.B., M.C., D.F.C., M.Inst.T.

Feb. 12. Joint R.Ae.S. and Helicopter Association Lecture: "Vibration Problems Associated with the Helicopter," by O. L. L. Fitzwilliams, A.F.R.Ae.S.

Feb. 13. R.Ae.S.: Graduates and Students Section: "The Area Rule," by W. T. Lord.

Feb. 13. Kronfeld Club: Czechoslovakian films.

Feb. 13. Royal Society of Arts: "Development and Use of Glass Fibres," by A. Hudson Davies, O.B.E., M.A.

Feb. 14. R.Ae.S.: Main Lecture: "The Fairey Delta," by R. L. Lickley and P. Twiss.

Feb. 15. Institute of Navigation: "Navigation and Traffic Control Over the North Atlantic," by D. O. Fraser.

Feb. 16. British Interplanetary Society: Chemical Demonstration by Dr. J. Diederichsen.

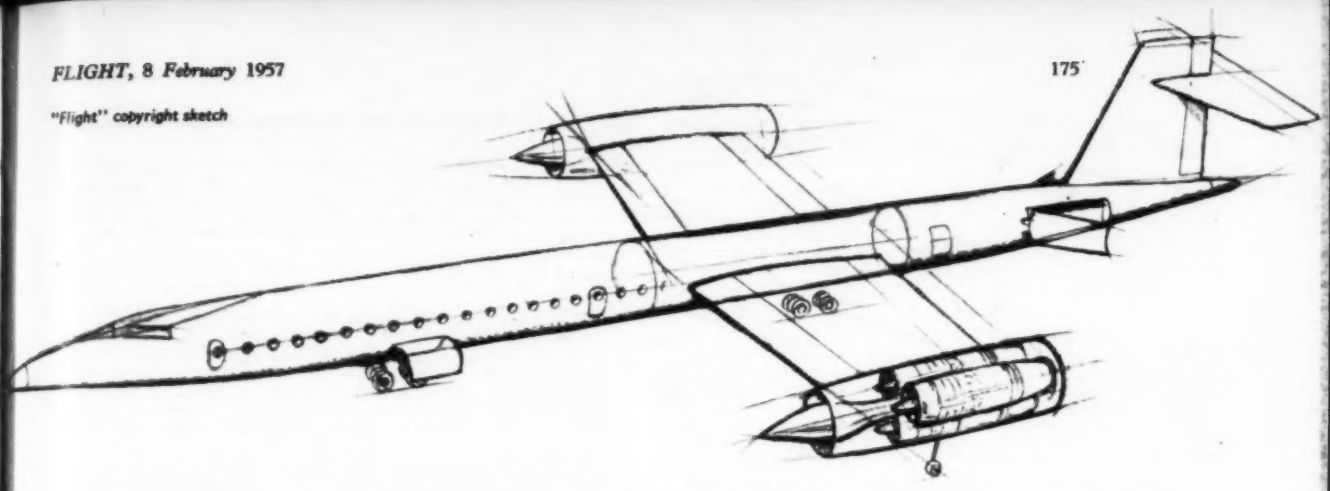
May 24-June 2. Paris Aero Show, Le Bourget.

Sept. 2-8. S.B.A.C. Show, Farnborough.

R.Ae.S. Branch Fixtures (to Feb. 20)

Feb. 13, *Leicester*, "Flight Development of Modern Prototype Aircraft," by C. F. Bethwaite. Feb. 15, *Brough*, Annual Dinner and Dance; *Birmingham*, President's Night. Feb. 18, *Henlow*, "New Methods of Approach to Airworthiness" by W. Tye. Feb. 19, *Belfast* Lecture on "Welding," by K. A. Peel. Feb. 20, *Bristol*, "Viscount," by B. E. Stephenson; *Brough*, "Prospects and Problems in the Use of Nuclear Energy," by Prof. G. F. J. Garlick; *London Airport*, "Independents v. State Airlines," by M. H. Curtis; *Manchester*, "Flying Experiences" by Capt. O. P. Jones; *Southampton*, Branch Prize Papers; *Weybridge*, "Investigation of Aircraft Accidents," by E. L. Ripley.

"Flight" copyright sketch



Sketch of a hypothetical 100-passenger, Mach 1·9, 1,250 m.p.h. transport capable of single-stop London - New York operation. Gross weight would be at least 250,000 lb, with power provided by six turbojets of about 20,000 lb sea-level static thrust each. Cruising altitude would be 60,000 to 70,000ft. Fuel—over 15,000 gal—would have to be stowed in the wings, the entire fuselage centre section and possibly in the fuselage keel. Droop-snoot leading edges and blown flaps would be provided for acceptable low-speed behaviour.

SUPERSONIC AIR TRANSPORT

Pleasant Dreams and Hard Facts

By J. M. RAMSDEN

THE supersonic twinkles which now light the eyes of all Britain's transport aircraft and engine designers are the result of a train of thought that might be summarized as follows.

The long-range subsonic jet transport market has been conceded to the DC-8 and 707. The temptation to compete was strong, and Ministerial heads were swayed by splendid throughts of British-built, British-operated jets in Atlantic service by 1962. The D.H.118 was proclaimed, only to be dropped when it became clear that its specification would be difficult to achieve, and that the cost of the prestige it might bring could never be recovered by export sales.

The short/medium-range market (continues the train of thought) is being fought for on more than equal terms, with Viscounts, Vanguards, Britannias and Comets all penetrating American preserves. This market appears to be open to the sale of possibly 1,500 more aircraft by 1970*, but there are already nine types—five jets and four turboprops—competing for it.

The question of what to build next has probably never been so difficult to answer. One airline market is closed, the other already highly competitive. And military orders, dwindling with the changing pattern of defence, are not likely to sustain the industry as they have in the past.

What other commercial markets are open to support the world's second largest aircraft industry? Clearly there are big opportunities in the short-range, local service, cargo, S.T.O.L., V.T.O.L. and helicopter markets, and in the executive, business and agricultural fields. But, large and fruitful though these markets are, they are not big enough to reward the whole industry. A new market must be found; it must be a new kind of market, and the industry must be the first into it. Only by so doing can our industry maintain its present size.

For a year or more Avro, Bristol, de Havilland, Handley Page, Rolls-Royce, Vickers-Armstrongs and other firms have had small initial project teams studying the supersonic transport. Each firm has pursued its own line of thought, and has come up against the same hard facts—that success, if it is to be achieved within 15 years, depends upon a programme of research and development so costly that the country could afford to support only a united effort upon one project (or *perhaps* two).

This has led to the formation of a committee, reminiscent of the one formed in 1943 under Lord Brabazon's chairmanship, but different in that a single transport requirement is being studied by representatives of the industry and the actual customers—the Corporations and the Ministry of Supply. This consortium—whose chief task is the gathering of basic data—has, under the general guidance of the R.A.E., to resolve delicate political and industrial issues as well as the technical problems of commercial supersonics. It is with the technical problems only that the present analysis will attempt to deal.

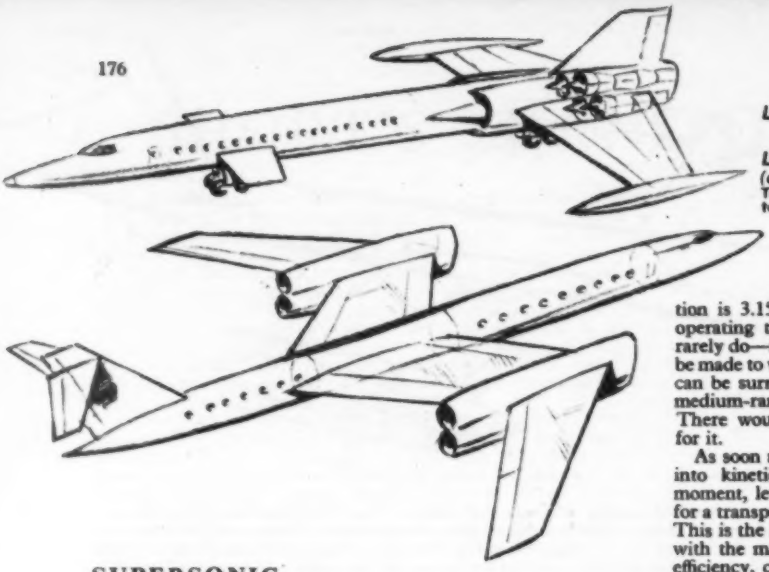
Our intent is to do some broad brushwork—to touch upon the fundamental problems without being sidetracked by issues which, though fundamental to ultimate success, can be set aside at the initial project stage. For example, having achieved a promising basic layout, we might find that the sequel is a nervous breakdown for the flutter engineer, the undercarriage designer, the production engineer, the stability and control aerodynamicists, the cabin-air system engineer, the windscreen designer, and other technicians too numerous to list.

Nevertheless, what are the fundamental problems? We shall assume for the purpose of this study that the aim must be to produce, for service by 1970 in order to capture the market (and even this may be too long a time-scale), a supersonic transport which: (1) has transatlantic capability—preferably non-stop; (2) can use existing first-class airports; (3) offers a high standard of safety, particularly in the low-speed regime; and (4) offers a level of economy which, though worse than previous standards, is not so poor that fares will be too high even for the attraction of the very high speed offered.

Let us consider first a transport with a Mach number of 1.5. The appropriate true airspeed at cruising height is about 990 m.p.h. The familiar range equation for transport aircraft enables us to determine the relationship between this speed and the other fundamental factors of range, weight, and fuel consumption.

We shall assume (1) that our Mach 1.5 transport must have non-stop transatlantic capability—say 6,000 statute miles still-air range for a practical London-New York stage length of 3,600 miles; (2) that it will have engines with a specific fuel consumption of 1.4 lb/lb/hr, a figure well within the bounds of reasonable expectation using present-day fuels; and (3) that cruising drag at Mach 1.5 will be as low as can possibly be achieved to attain a lift/drag ratio of 6. [*Contd. overleaf*]

* *See "Flight," December 14, "The Hungry Airlines, Part 2: The Medium-Haul Market."*



Left, above: Another hypothetical transport for Mach 1.9.

Left, below: A "just supersonic" (M=1.2) design with an M (or, alternatively, W) wing, with a 45-deg. sweep-angle. The aim is to establish a subsonic flow field and, at the same time, to minimize wave-drag. This the design does, with a low centre-of-pressure movement; but structure weight will be high.

SUPERSONIC AIR TRANSPORT . . .

Having fixed these *desiderata* it is then possible to determine the resultant relationship between the all-important factors of basic weight, fuel weight, and payload. The result is an aeroplane with no payload at all, and which would fall into the Atlantic 800 miles short of New York.

This is an unpromising start, and adjustments will have to be made to the specification. First, the range sights could be lowered to single-stop (Gander or Keflavik) transatlantic operation—let us say to 4,400 miles still air range (2,600 miles practical stage length). Specific fuel consumption could, at the most optimistic reckoning, be reduced to 1.2 lb/lb/hr. Drag could conceivably be reduced—possible to yield an L/D ratio as high as 7—by close conformity to the area rule.

All this presupposes immensely costly and lengthy research, much of it in fields which are only beginning to be explored. But—airily assuming that postulations are accomplished facts—we can take a fresh look at the range equation to see what sort of payload emerges. Our assumptions are now a cruising speed of Mach 1.5, a still-air range of 4,400 miles, a specific fuel consumption of 1.2, an L/D of 7. A payload which works out at about 8 per cent of gross weight emerges, provided that a basic weight of about 40 per cent can be achieved. This sort of payload, small though it would be, appears to present a reasonable proposition for further study, though its feasibility depends upon a most sweepingly optimistic set of assumptions—particularly the achievement of a cruising L/D ratio of the order of 7.

Price of Technical Failure

The proportion of payload would be very sensitive to variations of L/D and consumption; if, for example, they came respectively to 6 and 1.3 through technical failures—and these are reasonable figures in the light of aerodynamic and powerplant progress—our proportion of payload drops from 8 per cent to zero. The extent to which success depends upon great technical achievements in the aerodynamic and powerplant fields is clear: and even with such technical success the non-stop Atlantic dream would not have been attained.

Nevertheless, assuming that an 8 per cent payload *is* achievable, it is worth comparing the economy of such a transport with that of the types it might replace—say the 707. It must of course be borne in mind that, by all the laws which should govern a perfect transport market, the operating cost of a new vehicle should be no higher, and ideally ten or more per cent cheaper, than that of its predecessor.

We shall apply the costing formula as outlined in the paper presented by Mr. G. F. Worley of Douglas at the I.A.S. meeting in San Diego in August 1956, omitting its details for the sake of brevity. The outcome is that the ratio of revenue-earning ability to operating cost for our Mach 1.5 transport of the stated specification is 3.15. The comparable revenue-cost ratio for a 707 also operating the Atlantic with one stop—which, of course, it will rarely do—is 5.2. It seems that though a Mach 1.5 transport could be made to work—assuming that some formidable technical hurdles can be surmounted in the time available—it would be limited to medium-range operation and it would be very expensive to operate. There would, on the last count alone, be a very small market for it.

As soon as we begin to look at higher regimes of Mach we run into kinetic-heating difficulties. But, ignoring these for the moment, let us do some more speed/range/cost sums, this time for a transport with a cruising Mach number of 2.5, or 1,650 m.p.h. This is the higher supersonic realm wherein the jet engine, made with the materials we know or can foresee, reaches its optimum efficiency, compensating considerably for the difficulty of raising the lift/drag ratio as Mach number increases.

If we aim our Mach 2.5 transport at a 6,000 statute mile transatlantic still-air range, anticipate a specific fuel consumption of 1.5 and design for an L/D of 6—all reasonable aims—we find that to provide for any payload at all we should have to achieve a basic weight of 30 per cent. This is probably out of the question: 40 per cent would be optimistic, and 45 more likely with the low-speed lift devices which would have to be built in.

More L/D Wanted

Non-stop transatlantic operation at Mach 2.5 thus appears to be utterly ruled out, unless L/D ratios of at least 10 and a Mach 2.5 specific consumption of the order of 1.1 can be attained. The likelihood that either—still less both—will be achieved in the next ten years seems extremely remote. An L/D of 10 at Mach 2.5 appears to be so far out of reach—employing known principles—as to be laughable. L/D ratio can be increased at high Mach by low aspect-ratios and ultra-thin wing sections; but these measures involve, respectively, poor low-speed characteristics and (assuming sections as thin as 3 per cent) formidable structural difficulties. Aspect ratios low enough to make any significant improvement in L/D would inevitably necessitate elaborate engine-assisted low-speed lift-increasing devices which, besides taking a long time to perfect, will assuredly eat heavily into basic weight and payload. The "ifs" and "buts" of this theme could easily occupy many pages. For example, if a low aspect-ratio is adopted, a radically different approach to stability and control will be required; for example, downwash would render ineffective a conventionally situated horizontal tail.

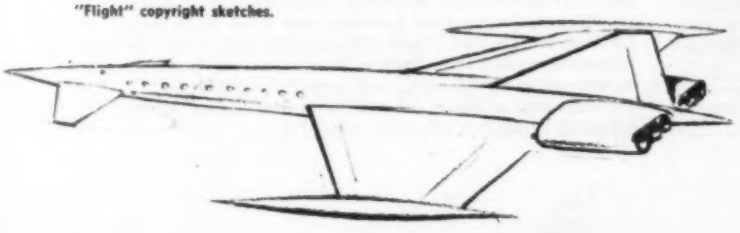
Continuing for the moment to ignore Mach 2.5 kinetic-heating problems, let us see how an aeroplane of this speed would work out on single-stop transatlantic ranges with "reasonably optimistic" assumptions for L/D ratio, fuel consumption and basic weight —say, respectively, 6, 1.3 and 40 per cent.

Again, these figures presuppose aerodynamic, powerplant and engineering accomplishments of immense magnitude. But the payload which would be the reward of success would be of the order of 10 per cent—sufficient to warrant more detailed brushwork. Operating cost would be high compared with that of the 707; but there *might* be a market for any reasonably economic transport capable of flying from London to New York in four hours, including an hour on the ground at Gander.

A Mach 2.5 machine would show better economics on medium stages: but it would still be extremely expensive to operate in comparison with long-range subsonic jet aeroplanes, and block speeds would be a relatively small percentage of cruising speed because of the large amount of trip-time devoted to "comfortable" axial accelerations and decelerations—i.e., not more than 0.2 g.

But, of course, the dream of transporting infants and old ladies at Mach 2.5 is melted away by kinetic heat—at any rate for 10 to 15 years, until materials are developed to permit safe and comfortable flight at oven temperatures of about 400 deg F, and to withstand the effect of rapid heating and quenching during

"Flight" copyright sketches.



A Mach 2.5 airliner, made of steel or titanium-sandwich. Such a machine would operate at high powerplant efficiency (thermal and propulsive) but poses severe operational problems, not the least of which is heat-transfer. The intakes in this configuration might be favourably disposed in relation to the shock-wave on the wing trailing edge, but the maintenance of optimum conditions would be extremely critical.

acceleration and slowing down. Aluminium and magnesium alloys suffer drastic deterioration in their physical properties at about Mach 2, and after prolonged heating never regain their low-temperature properties. These materials must be abandoned, and replaced by steel and titanium. But it is very difficult to obtain efficient structures with such denser materials under compression loads (the stress-case which accounts for the greatest proportion of the weight of an aircraft structure). The use of titanium in honeycomb-sandwich form appears to provide the most promising answer on all counts, but it is an expensive material, and notoriously difficult to fabricate even in single-panel form. Titanium-sandwich airframes will take years of expensive research to perfect, and it is probable that the cost of their fabrication will be several times greater than that of present-day structures. The Mach 2.5 transport appears to be ruled out as the first step in commercial supersonics; but it may well be the second step.

Mach 1.9 The Right Choice?

It remains to examine the possibilities of flying somewhere between Mach 1.5 and 2.5; in other words to choose a speed which avoids the penalties of restricted range and low efficiencies on the one hand and kinetic heating problems on the other. Without a computer it is an arduous business to hit upon the optimum combination of all the variables: but, with non-stop transatlantic ability as the objective, it appears that a Mach number of rather less than 2, say 1.9 (1,250 m.p.h. t.a.s.), may provide a good starting basis for further exploration. If a structure weight of 40 per cent can be achieved, and a specific fuel consumption of 1.2 and an L/D of 8, then a payload of 8 per cent comes within sight. And if single-stop Atlantic operation were acceptable, a payload of 12 per cent could be achieved for the same drag, powerplant and basic-weight criteria.

Such a transport would be expensive to operate—about 20 per cent higher than the DC-8 or 707 assuming revenue to be comparable. But the technical difficulties, though still formidable, might be capable of solution in the time. It is conceivable that a spirited research programme could, by the mid-sixties, find the answers to the vicious-circle problems of: (1) achieving high L/D for Mach 1.9 long-range cruising while retaining perfect control coming in on a G.C.A. at perhaps 200 kt; (2) achieving low consumption without prohibitive powerplant weight and temperatures; (3) obtaining good field-performance without recourse to heavy powerplant-energized lifting devices; and (4) producing structures more efficient than those of today to withstand the higher loadings, again in order to keep basic weight down.

This is quite a catalogue of problems, but—with others too many to recount here—they will have to be resolved before the dream of supersonic flight can come true.

We shall preface our conclusions with the opinions expressed recently by Lockheed and Douglas (see January 11 and 18 issues) on the subject of supersonic transports. Mr. Hall L. Hibbard, senior engineering vice-president of Lockheed said to *Flight's* representative:—

"I say that the industry—and I hope it is Lockheed—will have a prototype flying in eight years' time, and in operation four to five years after that . . . I should say Mach 2.7 is about right. . . . We would have plenty of power for take-off, plenty of wing for very-high-altitude cruise, and certainly blown flaps and reverse thrust for landing. . . . As for the thermal barrier, sure it's right there, but we will just fly above it at 100,000ft. The airplane will have to go some ways. We think everything is fitting into place just perfectly."

By contrast, Mr. G. F. Worley of Douglas said:—

"It appears that the short-range capability and the high operating costs of the supersonic transport, together with the small time-saving at the ranges for which a supersonic airplane is suitable, will limit the air transport field to subsonic aircraft through the 1960s. By 1970 technical advances will probably justify *beginning* [our italics] the design and development of supersonic transport types, but it is not likely that they will be performing any important part in the transport economy."

These are opinions expressed by firms of great repute, each with considerable practical supersonic experience; the fact that they differ so fundamentally is a measure of the problem. Someone is right, someone is wrong; a fact of which we are aware in presenting the conclusions of the present study.

Conclusions

Our analysis of supersonic transport has been restricted to the basic issues; but it is possible to conclude that, for the first step, the right choice of speed might be Mach 1.9, between Mach 2.5 kinetic-heating problems and the low efficiencies of Mach 1.5. For non-stop Atlantic operation the payload would be small, say 60 passengers, and operating cost 20 per cent higher than 707 levels. There *might* be a market for such a transport, if the immense technical difficulties, i.e., the L/D, consumption and basic weight figures required, could be resolved in time for service by 1970. This means that a prototype should fly by 1965.

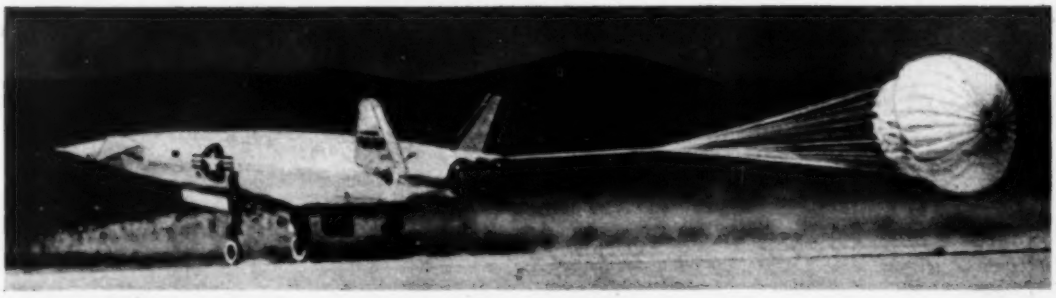
Single-stop Atlantic operation would not be acceptable at this speed; but for medium-haul (say 1,500-mile) routes a Mach 1.9 specification might be devised to offer, by 1970, 100-passenger-plus payloads and an economy competitive (but not comparable) with subsonic jets. There would appear to be a probable, if limited, market for such a machine.

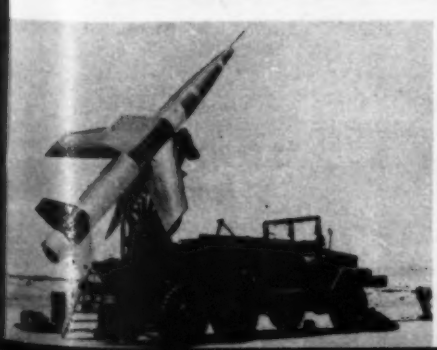
Finally, it appears that commercial supersonics may not become established until speeds of at least Mach 2.5 can safely be achieved—perhaps, with an all-out effort, in under 20 years' time.

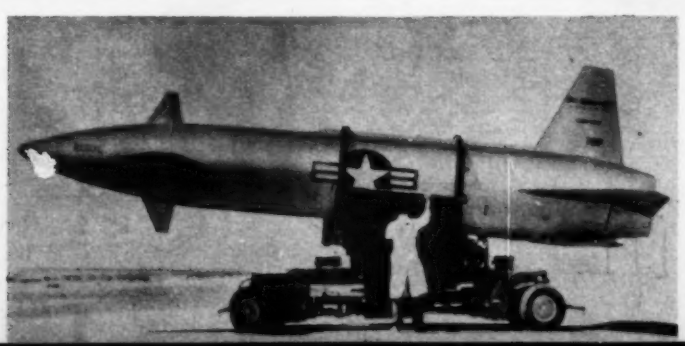
As Sir Arnold Hall said in his review of the subject in his recent Wright Lecture (*Flight*, December 28, January 4 and 11): "It would be imprudent to suppose that [Mach 2.5] could be reached quickly without substantial experience in this regime of flight."

FOUR NEW SHAPES IN THE GUIDED-MISSILE FIELD

On p. 167 some information is published relating to new types of American missile or test vehicle. These are the devices in question. At lower left is the Martin/Cornell Laboratory Lacrosse on its launcher; next above is a North American X-10 test vehicle landing at Patrick A.F.B.; on the right is a Lockheed X-17 research vehicle being fired at Patrick; and at the centre, below, is a Bell GAM-63 Rascal, the present standard U.S.A.F. air-to-surface nuclear missile, mounted on its ground-handling vehicle at Holloman Air Development Center, New Mexico.







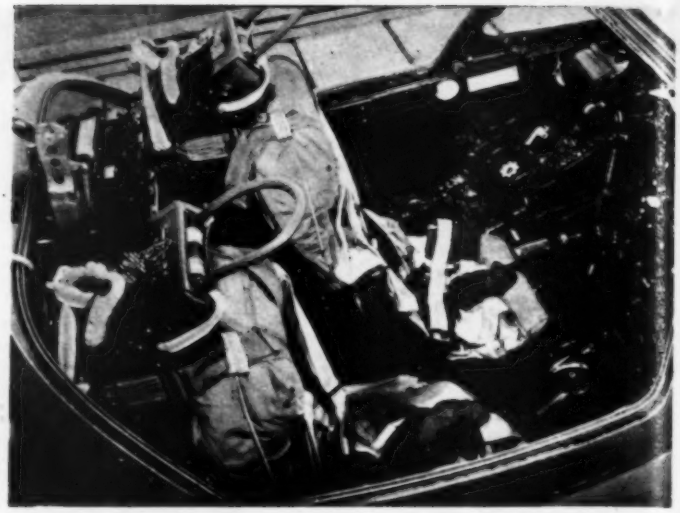
Commonwealth Courier

THE seven de Havilland Comet 2s which had been delivered to the R.A.F. by the middle of last month had by that time accumulated a flying time of 1,400 hr. Two of them, on December 20 and 21, made eight return trips between Lyneham and Cyprus to bring troops home for Christmas. The flying study on this page emphasizes the handsome lines and elegant finish of the Transport Command machines. It shows one of the more recently delivered aircraft of the batch whereon the "cheat line" runs along the line of the windows, and not below them, as in the picture at bottom right. The view immediately below was secured as one of the Comets was about to leave for Malta, and is a reminder that in November last year one machine made two return trips to the George Cross Island in one day, carrying crews for the Hastings and Shackletons which were to drop paratroops in Egypt. During recent critical months a regular Comet service has been maintained between England and the Allied Headquarters in Cyprus. The top right-hand picture shows a Comet undergoing inspection at Lyneham on its return from Cyprus —in which connection the makers claim that the Comet 2s have shown a higher rate of serviceability than any previous aircraft operated by Transport Command. During the first month of operation a single machine put in 80 hr of flying training. Seen at Changi, Singapore (centre right) is the arrival of the first R.A.F. Comet 2.

ROYAL AIR FORCE TRANSPORT COMMAND
670

EXIT FROM the SEA VENOM

Martin-Baker Mk 4 Seats in Service



Two Martin-Baker Mk 4 lightweight ejector seats in their standard Sea Venom FAW.21 installation. The parachutes are in horseshoe-shaped containers at shoulder-level, wedge-shaped cushions supporting the small of the back. Leg-restraint harness is fitted. The observer's seat tilts forward when the hood is opened.

AT the S.B.A.C. display last year a de Havilland Sea Venom FAW.21 was shown for the first time with its two ejection seats, but details of the layout were obscured by a black cloth cover. Photographs of Sea Venoms operating from carriers during the Port Said operations in November showed that Martin-Baker Mk 4 lightweight ejection seats had reached the squadrons; and information on this particularly difficult installation has now been released.

The design work was undertaken jointly by the de Havilland military design and development team at Christchurch and the Martin-Baker Aircraft Company at Chalgrove and Denham. Since priority was given to Mk 4 installations for trans-sonic fighters under development, the Sea Venom adaptation was started some time after the Mk 4 seat first became available.

It was clear from the first that, for the Sea Venom, the whole cockpit layout would have to be revised and that the ejection seat itself had to be specially adapted. Two of the larger Mk 3 seats had fitted quite comfortably into the side-by-side cockpit of the Vampire trainer, but the cockpit of the Sea Venom was 4in narrower and contained much radar equipment. In September 1954 the project was begun and a Mk 21 was flown to Chalgrove, Martin-Baker's airfield. A spare fuselage was despatched to the factory at Denham for detailed study.

It was found that the lightweight seats could be accommodated in the Sea Venom cockpit without re-designing the existing canopy. In October 1954 the first Martin-Baker mock-up was ready and the company was asked to proceed with the design. The aircraft and fuselage were returned to Christchurch and work began on the re-positioning of all the equipment in the cockpit. The only items left in their original position were the flying and engine controls.

One of the most difficult problems concerned the observer's position, which had to be moved 5in further forward and so arranged that the back of the ejection seat hinged forward from its base prior to ejection, in order to give adequate clearance between the back of the seat and the rear canopy arch.

A large spreader-plate was added to the floor to allow for reaction loads; and strong fittings were mounted on No. 2 bulkhead to locate the seats in the fore-and-aft direction. Care was taken to ensure reasonable clearance between equipment for the sake of servicing, and a number of general modifications were also incorporated. When the fuselage had been fully adapted, structural tests under ejection loads were carried out.

At a final meeting the cockpit and safety equipment were approved and the design was tested when two dummies were ejected from a cockpit rig on the ground. The dummies were correctly shaped and balanced and dressed in rubber boots, immersion suits and full flying equipment. After being retrieved in a net they were found to be free from scratches or abrasion, showing that they had made safe, clean ejections.

It was undesirable for the crew to eject without first jettisoning the canopy, as it has a fore-and-aft structural member. An interlock between canopy and seat was therefore incorporated. It consists of a safety pin in the seat-firing mechanism, so arranged that until the canopy physically leaves the aircraft the ejection-seat blind cannot be pulled. This is considered better than attaching the blind direct to the canopy-locking mechanism, which might be damaged by enemy action. The interlock is also arranged to operate when the canopy is opened by the normal access handle—a particularly necessary safeguard, since the canopy is specifically designed to facilitate under-water escape in case of an unsuccessful catapult take-off.

In addition to releasing a safety pin in both ejection seats the opening of the canopy is also set to trigger springs in two telescopic tubes to move the observer's seat to the forward position, where it is locked by an over-centre linkage.

The Mk 4 seats now fitted to all Sea Venom Mk 21s—the first Service installation—can accommodate the 80ft/sec long-stroke ejection gun and the special time-delays which permit both runway-level and high-altitude automatic ejection. A similar installation is now ready and available for the R.A.F.'s Venom N.F.3. In this case seats and superstructure are identical with those described above, but the cockpit layout is different. The weight penalty of the two ejection seats in the Sea Venom Mk 21 is only 100 lb, which Naval air crew will consider a worthwhile sacrifice for the added peace of mind. The new seats are also more comfortable than the earlier fixed type.

OLYMPUS 6 PROGRESS

LAST week Bristol Aero-Engines, Ltd., announced the completion of an officially observed 150-hr run for the Olympus 6 turbojet under type-test conditions. The run was completed at the design rating of 16,000 lb dry thrust without afterburner, and the engine is now being examined with a view to issuing the official type-test certificate.

Sir Alec Coryton, chairman and managing director, stated: "This test is a culminating point in development to the 16,000 lb-thrust rating; the last step before the engine is cleared for production . . ." Further development to higher power is already under way, and we are allowed to state that thrusts of over 17,300 lb were recorded during the current test run. These figures are appreciably in advance of any which have been published for any other aero engine. The de Havilland Gyron, Orenda Engines Iroquois, Pratt and Whitney J75 and J58 and probably more than one Russian engine are all basically larger; but none of these has yet been associated with a type-test figure as high as 16,000 lb.

IMPROVED SOVIET TRANSPORTS

IN the second half of 1956 the Russian airline Aeroflot began regular operations with a new version of the Il-14P twin-engined transport, designated Il-14M. The principal modifications in this model are a forward extension of the fuselage by 3.3ft and complete rearrangement of the passenger seats. The standard of comfort is generally higher and new radio is fitted. All-up weight of the aircraft is quoted as 37,525 lb and range as 500-930 miles.

It is also learned that the Russian Arctic expeditions are now equipped with a new variant of the Li-2 (licence-built Douglas Dakota) designated Li-2B. This model is suitable for high-altitude operation by virtue of ASZ-621R engines with TK-19 superchargers. Oxygen is provided for the crew and passengers. The new version is intended for passenger work in mountainous regions or for meteorological reconnaissance. Operation at heights above 26,250ft is foreseen. The Li-2, a standard civil and military transport, has been built in very large numbers.

An Hispano HA-1112-M1-L (Me 109 development) of the Spanish Air Force. The engine is a Rolls-Royce Merlin 500-45 driving a four-blade Rotol airscrew. Note the streamlined rails for a total of eight R.Ps.

AIRCRAFT INTELLIGENCE

U.S.A.

Re-engined Boeing B-52. A version of the eight-jet Boeing B-52 Stratofortress powered with Pratt and Whitney J75 engines (each of 15,000 lb thrust approximately) in place of the present J57s (10,000 lb approx.) is being developed by Boeing with the endorsement of Strategic Air Command.

Hughes Model 269. The model 269 is a new Hughes helicopter—a two-seater weighing 850 lb empty, having a cruising range of 170 miles at 75 m.p.h. and powered with a four-cylinder Lycoming O-340-A1A engine. Main rotor diameter is 25ft. *Aviation Week* reports that U.S. Army interest has progressed to the point of "processing an order for an evaluation quantity—five to ten of the copters."

Canada

DHC-4 Caribou. Now known as the Caribou, the DHC-4 is already the subject of American and Canadian orders. Two prototypes will be built to meet the requirements of the Canadian Army and seven machines are being acquired for the U.S. Army, which Service was granted exemption from its 5,000 lb limit as the machine is considered to be a "cargo" type. A 2½-ton payload is reported, and landing and take-off runs should be about 500ft. Although the eventual use of turboprops is being studied, Pratt and Whitney piston engines will be initially installed. The undercarriage is of nosewheel type.

France

Fouga Magister. Following demonstrations in the U.S.A., the Grumman Aircraft Corporation has taken an option on a licence to construct the Fouga CM-170R and CM-175 versions of the Magister jet trainer. These models are for land and naval use respectively. Negotiations have also been under way in Germany and in other European and Middle East countries. Having regard to this widespread interest, Air Fouga, in agreement with the French Air Ministry, are said to have adopted measures intended "through a distribution of licences and co-operation programmes, to establish a construction project in France and abroad for approximately a thousand Magisters."

Leduc 022. Since its flight on December 26, this supersonic ramjet research aircraft has made about ten flights with the SNECMA Atar D.3 turbojet in operation. A French news report states: "After solving all the utilization problems regarding this jet engine installed for the first time at the inside of the thermo-propulsive pipe, a new series of flights will be undertaken with the pipe ignited. Even at the present date, the performance of the aircraft during take-off and landing, carrying more than 75 per cent of the maximum weight, is more or less identical to the performances of present French fighter planes."

S.E.210 Caravelle. The second prototype of the Caravelle twin-Avon transport has now made over 54 flights, totalling 200 hr. It has been fitted out for tourist class travel with 70 seats, and a noise level of 84 decibels is reported to have been recorded in the cabin. This compares with 85 decibels for a luxury American car of Cadillac type. The machine is now in the workshops at Toulouse before its American tour, scheduled for next May.

Poland

Record Flights. It is learned that on December 28 last a TS-8 Bies trainer, fitted with a WN-3 engine of 320 h.p., established a new international height record for light piston-engined aircraft by achieving an altitude of 7,200 metres (23,620ft). The pilot was A. Ablamowicz. Previously the record was held by a Russian Yak-18, with a height of 19,790ft. On December 27 the same pilot had taken a CSS-12 prototype (this machine is a twin-engined transport) to 21,653ft, carrying a load of 2,240 lb. The height record established on the Bies is the first international record ever put up by a Polish aeroplane fitted with an engine of Polish design. The Bies—several prototypes of which are now flying—is in large-scale production for the Polish Air Force and for club use.

CONVAIR XB-58 HUSTLER
(Four General Electric J79-GE-1)

Span	55ft
Length	95ft

TWIN PIONEER SKI-LIFT

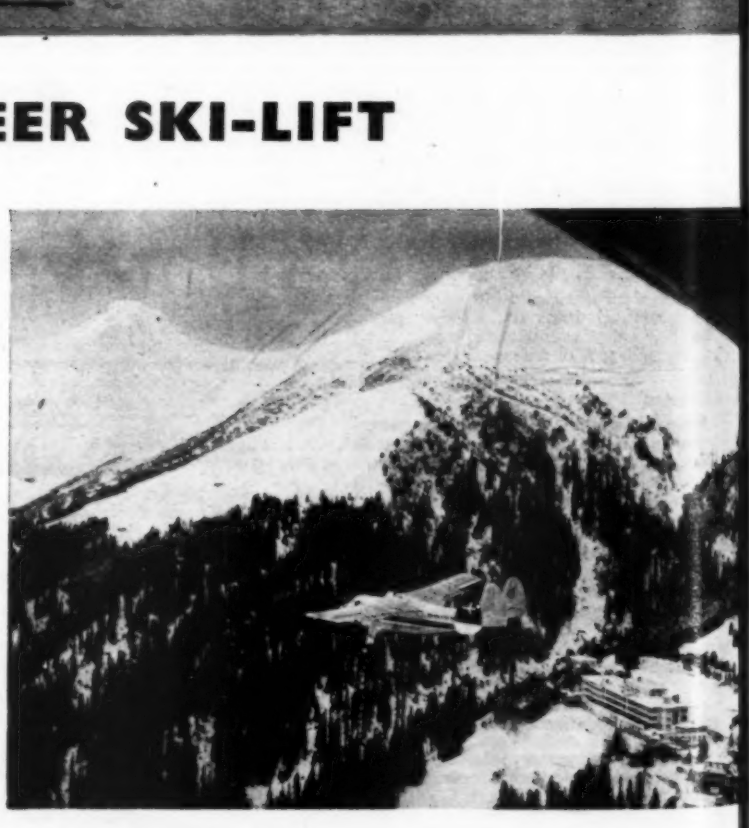
Britain's S.T.O.L. at Work in Swiss Airline Service

AS we recorded in our January 25 issue, the Scottish Aviation Twin Pioneer, complete with its recently awarded certificate of airworthiness, is now in scheduled passenger service with Swissair.

The particular machine, registered G-AOEO, is seen here against the spectacular background of St. Moritz, where it undertook trials before going into operation. In the picture above it is showing off its renowned take-off agility at the small St. Moritz airfield.

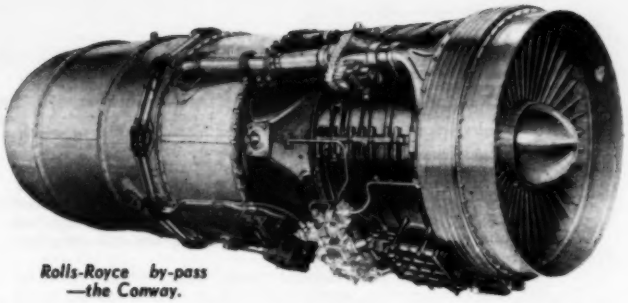
The aircraft has been chartered by Swissair from its makers for the two best months of the ski-ing season. It will operate, on a thrice-weekly basis, a regular "ski-lift" service from Zurich to Davos, St. Moritz, La Chaux-de-Fonds and Geneva.

If the Twin Pioneer fulfils Swissair's expectations, as we have no doubt it will, it is more than likely that the airline will place an order.



By-pass Assessment

A Plain Man's Guide to the Rolls-Royce Conway



Rolls-Royce by-pass —the Conway.

IT requires a rare clarity of mind to expound with simplicity upon technical subjects. But last week, at the Institute of the Aeronautical Sciences in New York, two Rolls-Royce engineers, Mr. A. C. Lovesey (assistant chief engineer, military types) and Mr. L. G. Dawson (chief project engineer) presented a lecture which was a model of its kind. Their subject was *The By-pass Engine for Transport Aircraft*, and rarely has the *raison d'être* of this type of engine been stated so lucidly.

The lecturers opened their talk by reminding their audience that the turbojet engine is now an accepted propulsion unit for transport aircraft (orders have been placed for over 300 jet transports). It seemed to them only a matter of time before the turbojet—operating blown flaps and deflected jets—entered the field of short-range transport aircraft as well.

Long-range stratosphere cruising speeds of 500 kt have been made possible by the high thrust : weight ratio of the turbojet engine combined with aerodynamic advances of the airframe. Cruising speeds above M = 0.9 are likely to require greater effort on aerodynamic improvement than upon engine design: the Douglas and Boeing high subsonic transports will be with us for many years.

But have we [asked the lecturers] found the best type of turbojet for this field of operation? The turbojet engine has made steady progress in the direction of better specific weight, better specific fuel consumption and greater thrust per unit frontal area. But the improvement of all three factors together is becoming more difficult; the design of an engine for a special duty is becoming an interchange between the three performance parameters. An improvement in specific consumption, for example, may usually be achieved only at the expense of higher specific weight.

In long-range transport aircraft the weight of fuel carried—about half the take-off weight and about four times the payload—is high, and for such aircraft the specific consumption will be the most important characteristic of the engine; for short-range operation engine weight becomes more important.

Consider the ways [continued the lecturers] in which a low specific fuel consumption may be achieved in a turbojet engine. As an example we have assumed a pressure ratio of 12:1, a compressor efficiency of 0.87 polytropic and a turbine expansion efficiency of the same value. The intake has been assumed to cause no loss. What are the principles involved?

In the case of the jet engine air is inhaled, compressed, its temperature further raised by burning fuel and then expanded through a turbine where sufficient energy is extracted to drive the compressor. The pressure aft of the turbine is greater than that pertaining in the intake and, by expanding the gas to atmospheric pressure, energy is made available for propulsion.

The gas is converted into kinetic energy by expanding it in a propelling nozzle; the thrust produced depends upon the mass and the velocity of the gas. For a given mass of air, the more fuel burned the higher will be the temperature aft of the turbine and the greater will be the pressure and the higher the velocity generated after expansion. This produces a greater thrust.

For the long-range transport we are concerned not only with the thrust produced but with the efficient conversion of the heat energy of the fuel into mechanical energy. This is represented by the jet velocity and the best use must be made of it to propel the aircraft.

The conversion of fuel energy into mechanical energy is governed by the thermal efficiency of the basic cycle, and is a function of the pressure ratio and the combustion temperature. The measure of conversion of the jet energy into propulsive effort is the Froude (propulsion) efficiency and is normally written in terms of the jet velocity. Or it may be written in terms of thrust per lb of air:

$$\frac{2}{1+\frac{\text{jet velocity}}{\text{flight speed}}} \quad \text{or} \quad \frac{2}{2+\frac{\text{thrust per lb} \times g}{\text{flight speed}}}$$

It appears that a high propulsive efficiency requires a low jet velocity and a low thrust per lb of air.

There are two fundamental relationships required to understand the problem: the relation between propulsive efficiency and thrust per lb (given above) and the relationship between specific consumption, thermal efficiency and propulsive efficiency. This is:

$$\frac{\text{flight speed ft/sec}}{\text{s.f.c. lb/hr/lb/thrust}} = 4{,}000 \times \text{thermal} \times \text{propulsive efficiency}$$

In Fig. 1 the propulsive efficiency, thermal efficiency, specific consumption and turbine inlet temperature are plotted against thrust per lb of air for a typical high-pressure-ratio jet engine. It will be seen that the propulsive efficiency falls off with an increase in thrust per lb of air or an increase in turbine inlet temperature. But thermal efficiency rises with increases in flame temperature, since the compressor and turbine have efficiencies of less than 100 per cent; if these components had no losses the thermal efficiency would depend on the compression ratio alone.

The point to notice is the opposing influence of the thermal and propulsive efficiencies on fuel consumption. It will be remembered that the specific consumption curve is the inverse of the product of the thermal and propulsive efficiency curves.

From the same graph it is interesting to note the extremely low

Fig. 1. Typical performance curves for a simple turbojet.

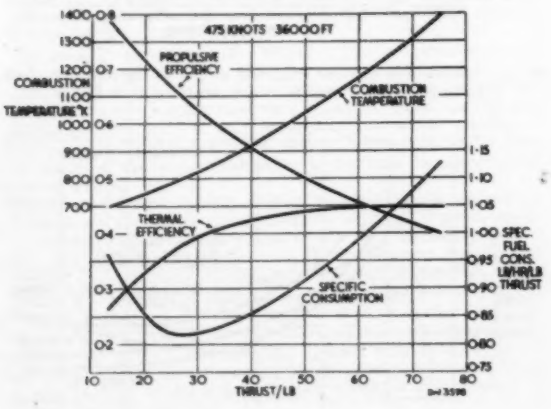
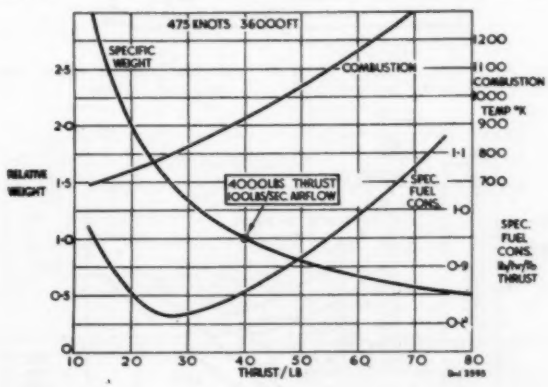


Fig. 2. Thrust per lb of airflow vs. engine weight (constant thrust).



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turbine inlet temperature—800 deg K or about 1,000 deg F—at which the minimum consumption occurs.

There would appear to be little wrong with this method of achieving a good specific consumption by operating the engine cool, although an examination of the effect on engine weight of varying thrusts per lb of air (Fig. 2) shows that the weight of the engine increases considerably as the minimum consumption is approached.

An engine giving the required cruise thrust when operating at the best consumption would have a high take-off thrust at its maximum permissible turbine inlet temperature. But it would be heavy, and this would offset the good cruise economy. In practice some compromise is made, and it is usual to cruise at a thrust per lb about 1½ times that corresponding to the minimum-fuel consumption.

Is there some way to defeat this consumption: weight relationship? It will be recalled that a big factor in obtaining minimum consumption from the jet engine is to achieve a high propulsive efficiency by working at a low thrust per lb of air swallowed. (The propulsive efficiency depends only on the final velocity of the air; it is not affected by the path of the air inside the engine.) This means that to achieve a fixed cruise thrust the engine must be designed for a large airflow and it is this which makes it heavy.

The turbines of the low-temperature jet engine are heavy because they have to deal with the total airflow at a low turbine inlet temperature and exhaust it into the jet pipe at a low pressure. It seems that the same airflow could be pumped with smaller turbines if they dealt with only part of the flow at higher temperature.

This represents the first step to the by-pass engine. (Fig. 3). In each case the low pressure compressors are the same and produce the same total airflow. In the by-pass engine the h.p. compressor, combustion chamber and turbines are scaled down, since they are dealing with only part of the total flow. The increased power per lb of air required from the turbines is obtained by running at a higher inlet combustion temperature to take advantage of the full power capacity of the turbines. It is clear that the by-pass engine is lighter since not only has the diameter of the high pressure rotating parts been reduced but the system is shorter.

The weight of the by-pass engine for the same airflow as the simple jet engine for various by-pass ratios is shown in Fig. 4. With a by-pass ratio of one-half—that is, with the flow through the by-pass duct equal to half the flow through the H.P. compressor—the reduction of weight for engines of the same design standard and stress level is of the order of 22 per cent compared with the jet engine.

An analysis of the by-pass engine at a cruising speed of 475 kt at 36,000ft shows that at the same thrust per lb, the by-pass engine gives nearly the same propulsive efficiency as the jet engine, while below a certain limiting thrust per lb it gives lower specific consumptions. The by-pass engine may be operated at a lower thrust per lb than the simple jet engine because it is lighter—the high pressure compressor is scaled down and the turbine system is smaller.

This is illustrated in Fig. 5, which shows the relative weight and specific consumption of the by-pass engine plotted against thrust per lb of total flow. It will be seen that at thrusts per lb greater than 35 the specific consumption of the engine with a by-pass ratio of 1 is actually worse than that of the jet engine. This is due to the fact that there are losses in the transfer of some of the energy from the hot gas to the by-pass flow. The cross-over point is delayed if the by-pass ratio is smaller, and most of the advantages of the by-pass engine are obtained with a ratio of not more than a half. This may be seen from Fig. 6 where specific fuel consumption at altitude is plotted against relative weight.

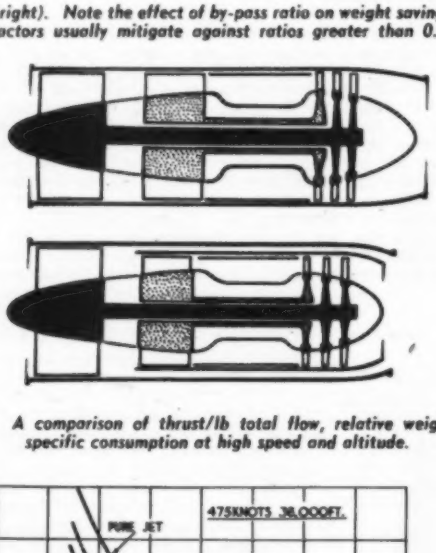
The advantages of the by-pass engine may be used in two directions: a reduction in weight for a given cruise consumption or a reduction in cruise consumption for a given weight. A representative cruise case (Fig. 7) shows a saving in weight of 15 per cent at a given consumption or a reduction in consumption of 5½ per cent for the same weight using a by-pass ratio of a half.

This comparison is somewhat modified when we take into account the drag of the powerplant. If the fuel flow divided by engine net thrust minus powerplant drag is plotted in addition to the ordinary specific consumption, it can be seen that the advantage of the by-pass engine is only reduced by a small amount when the pod drag is taken into account.

Accepting that the by-pass engine runs at a higher turbine inlet temperature than the jet engine it will, for this reason, weigh

Fig. 3 (below). The by-pass is shorter than the turbojet, and—as the h.p. compressor, turbine and combustion system are scaled down—can also be made appreciably lighter.

Fig. 4 (right). Note the effect of by-pass ratio on weight saving: other factors usually mitigate against ratios greater than 0.5.



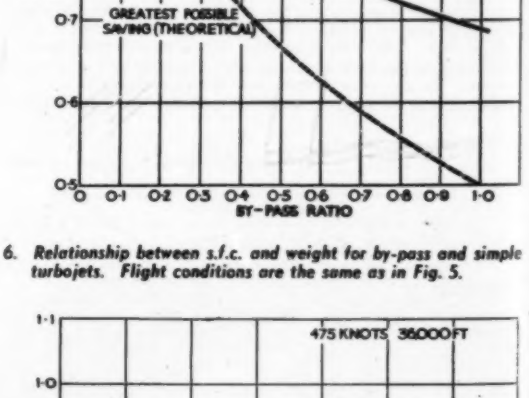


Fig. 5. A comparison of thrust/lb total flow, relative weight and specific consumption at high speed and altitude.

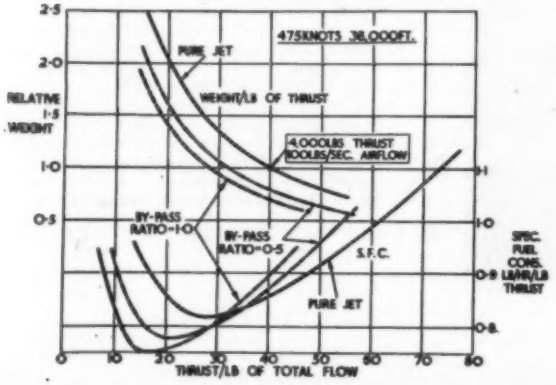
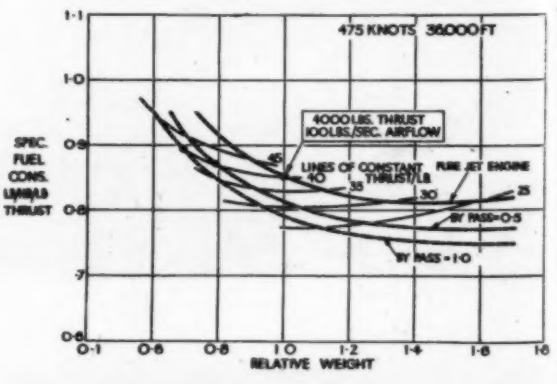


Fig. 6. Relationship between s.f.c. and weight for by-pass and simple turbojets. Flight conditions are the same as in Fig. 5.



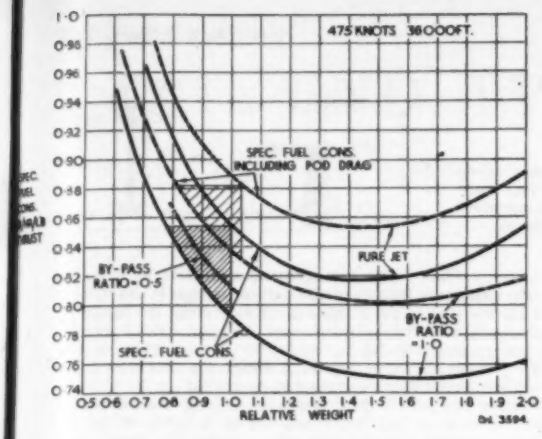


Fig. 7 (left). Installed advantages to be obtained from the by-pass.

Fig. 8 (below). Comparison of the pure-jet and the 0.5 ratio by-pass engine in the stand-off case at 15,000ft and 250 kt.

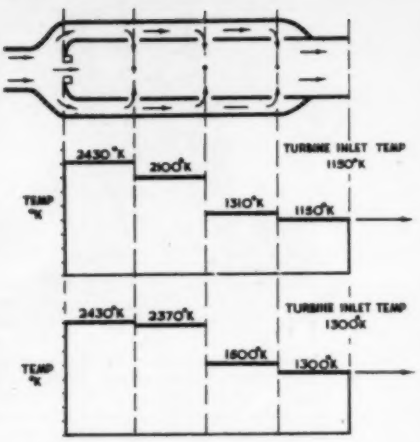
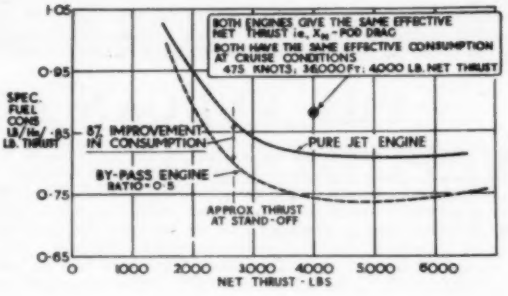


Fig. 9 (right). Typical flame-tube temperatures. The lower curve shows the effect of introducing additional fuel; the maximum temperature can remain unchanged.


BOTH ENGINES GIVE THE SAME EFFECTIVE NET THRUST i.e. X_{jn} - POD DRAG
BOTH HAVE THE SAME EFFECTIVE CONSUMPTION AT CRUISE CONDITIONS
475 KNOTS; 36000 FT; 4000 LB. NET THRUST
SPEC. FUEL CONS LB/HR/LB. THRUST
8% IMPROVEMENT IN CONSUMPTION
PURE JET ENGINE
BY-PASS ENGINE RATIO=0·5
APPROX. THRUST AT STAND-OFF
NET THRUST - LBS

less. But it is necessary in a by-pass engine to air-cool the turbine blades so that the metal temperatures are no higher than those which exist at the lower combustion temperature of the jet engine. This will be discussed more fully later.

The cruise case is not the only consideration for comparison; the relative take-off thrusts of the two engines must also be studied. If we consider the case in which the engines operate at the same specific fuel consumption, the by-pass engine will have a slightly higher mass flow than the jet engine to provide the same cruise thrust. If both engines are run up to the same turbine-blade-metal temperature it is obvious that the by-pass engine will give slightly more take-off thrust. If the engines are of similar weight the thrust increase is much more.

Another case for consideration is the relative merits of the two types of engine at reduced thrust under conditions of stand-off and stacking. Fig. 8 is a particular example of a typical stacking case—drawn for an aircraft flying at 15,000ft and 250 kt. As demonstrated already, the by-pass engine shows a better fuel consumption than the jet engine when operating at low thrusts per lb of air, and its advantage increases as the thrust per lb is reduced; in the case considered the by-pass engine uses 8 per cent less fuel than the jet engine. This factor could have an important effect upon short range operation, where fuel reserves are a high proportion of the total fuel carried.

It would indeed be unusual if the advantages offered by the by-pass engine were not accompanied by certain problems. Because it operates at a higher flame temperature the problem is to cool the parts in the gas stream to the level of those in the cooler jet engine—or better still to an even lower temperature.

The greatest difficulty is probably to be found in cooling the turbine blades. A method as old as the axial jet engine itself (it was used on the early German jet engines) is air cooling. But in spite of the excellent fundamental work done by N.A.C.A. and N.G.T.E. on this subject the industry has been reluctant to develop and apply blade cooling principles.

Steady progress in the practical application and manufacturing processes of cooled blades has taken place in England since 1947. During the past few years the major concentration of effort has been towards a satisfactory solution to the production problem.

Early air-cooled blades were of fabricated construction, but for quantity production there is considerable reluctance to rely on the brazing or welding of parts subject to high stresses. Various casting techniques have been developed, but again there is a preference for forged construction on the score of better fatigue properties. Satisfactory forging and extrusion processes which give a reliable construction with good cooling efficiency have been evolved, but there is still wide scope for better methods and even higher degrees of cooling.

The methods employed today are more than adequate in dealing with the higher turbine inlet temperature required by the by-pass engine, where two per cent of the air passing through the system is sufficient to provide the necessary cooling. Blade cooling [the lecturers pointed out] is only analogous to sodium cooling of exhaust valves on piston engines, and little progress would have been made in the latter technique if we had continued with uncooled valves.

Nozzle guide vane cooling follows much the same pattern as that developed for turbine blades, but the problem is much easier. The stresses are lower, the supply of air to a stationary part is easier and cast vanes—which ease the production problem of providing the necessary cooling passages—are acceptable.

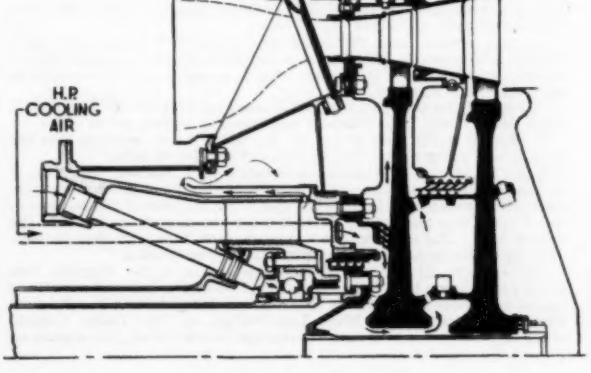
Flame-tubes might be expected to present major difficulties at the higher turbine inlet temperatures, because in the past they have not been entirely devoid of trouble even at moderate temperatures. Here it is misleading to think only in terms of the mean turbine inlet temperature, because combustion takes place at a substantially constant temperature which is independent of the mean final temperature.

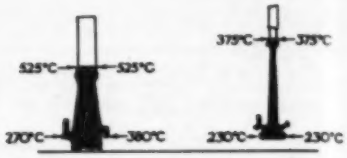
A flame-tube can be considered to be divided into a number of lengthwise zones into which a proportion of the total air is admitted progressively, zone by zone. The amount admitted to the first zone is usually between 15 per cent and 20 per cent of the total, and fuel is burnt rather richer than the stoichiometric value; this tends to give good flame stability and ignition characteristics. (The combustion temperature is approximately 2,400 deg K, or about 3,800 deg F.) Combustion is then either complete or is completed in the next zone by the addition of more air, and after that the process is one of diluting the hot gases with cold air. The major part of combustion is done in the first zone and it is fairly obvious that the temperature here remains substantially constant, irrespective of the final temperature.

Burning more fuel simply means that the hot region is extended to the next zone—but the temperature need be no higher. The principle is illustrated in Fig. 9. This has been well borne out in practice and it can be stated generally that if a flame-tube can be made to work well at moderate mean temperatures it can, by suitable proportioning, be made to work equally as well at high mean temperatures.

A lot of thought has gone into the design of turbine discs and a big advance was made when the material was changed from austenitic to ferritic steel. In early engines the turbine-disc

Fig. 10. Turbine-disc cooling by high-pressure air is shown in this part-section drawing of the Rolls-Royce Dart.





Figs. 11 and 12. Extensions of the turbine-blade roots on the Dart (left and extreme right) made possible a considerable reduction in temperature compared with earlier turbojet blades.

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rims were exposed to the hot gases and as they received a large heat-inflow from turbine blades, a high-temperature alloy was used. The disadvantages of this material were that it was difficult to forge and that its poor thermal conductivity resulted in large temperature gradients. The result was cracking in the blade-fixing serrations with repeated temperature cycles.

Ferritic material gave higher permissible stresses, but the temperature had to be reduced. This inspired the design of the "extended blade-root" which removed the turbine rim from the influence of the hot gases, and was first introduced into service on the Rolls-Royce Dart. The arrangement is shown in Figs. 11 and 12. An important feature of the turbine design is the flow of cooler air up the face of the turbine discs to prevent the inflow of the hot gas; with the extended blade root design the rim temperature did not exceed 375 deg C, whilst in the old design it was 525 deg C. This is shown in Fig. 11, a design that has now flown over 1¼ million hours in civil transport operation.

The authors concluded their paper by saying that they had attempted to make as fair a comparison as possible of the jet and by-pass engines. Their assumptions were that both types feature the same design technique and stress levels and the use of similar materials. The broad conclusion that they drew from the analysis was that the by-pass engine has the advantage in weight and consumption for the particular operation considered.

THE VULCAN ACCIDENT INQUEST

WHEN the inquest on the victims of the accident to the R.A.F. Avro Vulcan at London Airport on October 1 was resumed last week, the possibility of altimeter error as a contributory cause was suggested when the pilot, S/L. D. R. Howard, said in evidence that he believed his altimeter had been "gravely misleading" on the approach. He said further that his rate of descent would have been "fantastic" had he been at the height given by the ground controller a few seconds before the impact.

At the inquest, held in Ealing on January 30, the jury returned verdicts of accidental death on S/L. Edward J. Eames, aged 32, navigator; S/L. James G. W. Stroud, aged 29, second navigator; S/L. Albert E. Gamble, aged 35, air electronics officer; and Mr. Frederick Bassett, of A. V. Roe and Co., Ltd.

In his summing-up the coroner, Dr. H. G. Broadbridge, suggested there was nothing in the evidence to show criminal negligence on the part of anyone in the aircraft or on the ground; everyone seemed to be doing their duty as they thought right at the time.

S/L. HOWARD said that before leaving Aden he had received a signal from Bomber Command saying that he was to land at London Airport. Asked by the coroner if he had decided definitely to land there, S/L. Howard replied: "No. I was going to make an attempt to land, in view of the weather. If I could not, I was going to overshoot and go to Waddington, where it was promised that the weather would be very good. I decided to come down to 300ft by my altimeter, which represented to me a minimum approach altitude for London Airport of 150ft over the ground."

As the Vulcan came in at an approach speed of about 160 m.p.h.—"usual for that type of aircraft"—the talk-down from the ground controller was normal, and S/L. Howard said he acted on the information as soon as he received it. Before the talk-down was completed he hit the ground.

He now knew—although he did not know at the time—that he was outside the runway when he hit the ground. The last instruction he remembered before hitting it was "Three-quarters of a mile, 80ft high"—meaning he was three-quarters of a mile from touch-down and 80ft above the ideal glide-path. He increased the rate of descent.

"I asked the co-pilot, at a range I cannot remember, to look for the high-intensity lighting, which I was going to use to complete the landing. He told me he could see the lights over to starboard. All this time I was looking at instruments, not looking out.

"I looked for the lights as he told me, and I did not recognize the pattern. They were not what I expected to see. Immediately I had looked I went back on instruments, and he then told me I was very low, and to pull up. I did.

"At that precise time, the aeroplane just touched the ground and I decided to overshoot. This I tried to do, but as the aircraft accelerated it became obvious that I could not control it any more. It wanted to roll over to the right.

"I used all the control I had but I could not stop it and I realized I could do no more. My altimeter was showing slightly below 300ft.

"I shouted to the crew to get out and when it was apparent that the aircraft was going to roll into the ground decided to eject."

Asked by Mr. L. A. Prickett, representing A. V. Roe and Co., Ltd., if he had any idea what happened after hitting the ground to make the aircraft uncontrollable, S/L. Howard said: "At the time I did not know, and I could not understand why, because the aircraft did not hit the ground hard. But on recollection now, it must have been that the controls were damaged when the aeroplane hit the ground."

The coroner, Dr. H. G. Broadbridge, asked if the altimeter was gravely misleading him. S/L. Howard replied that he believed it was, but he did not know how it could be accounted for. He told Mr. Michael Eastham (appearing for Miss Ann Mailey, an Air Traffic Control assistant) that he held a Master Green instrument rating, the highest an R.A.F. pilot could have. He said that there was a known error of 70ft on his altimeter and he set 80ft as the height of London Airport a.s.l. He agreed that if he had been on the glide-path three-quarters of a mile from touch-down he should have been about 260ft off the ground. If the altimeter had functioned correctly he would have broken off his attempt to land.

AIR MARSHAL SIR HARRY BROADHURST, A.O.C-in-C. Bomber Command and co-pilot of the Vulcan, said that he left it to the judgment of S/L. Howard, as captain, whether he (Howard) tried to land or not. Asked by the coroner whether the talk-down was normal, he replied: "There was nothing in it to alarm you. It seemed perfectly safe."

Speaking of the lights, he said they appeared as a sort of misty glow on the starboard bow, and he immediately reported them. When the lights began to clear into a pattern he knew they were too low.

They hit the ground a glancing blow and he was so convinced that no damage had been done that as the pilot opened his throttles and the aircraft rose he said: "If we turn slightly left we can still make it."

But the pilot answered: "No, I am going to overshoot." Then he said: "I think we have had it." He called to the crew to get out, and ejected. Sir Harry tried the controls but got no response, then ejected himself.

He said that his and the pilot's altimeters were not coincident on the flight; there was an error of between 50 and 80ft between the two. Asked if he could account for the additional error in the altimeter, he answered that they now had established phenomena which might account for it.

MR. JOHN MANNING, G.C.A. controller, said that the Vulcan was about six miles out when he established contact with it. His screen did not show the aircraft's height above the glide-path; that was given to him by a meter operated by his assistant. The aircraft must have come down at a steep angle and touched the ground in a matter of seconds.

Replying to Sir David Scott Cairns, Q.C., Mr. Manning said that so far as the screen was concerned, the appearance to him of an aircraft on the ground or one passing over safely at a point, say, 150ft above would be exactly the same. "From the point 80ft high the meter showed a descent towards the glide-path. I cannot say with accuracy whether it had reached the glide-path. I can say it did not go below."

MISS ANN COLLINS MALEY, the tracker, said that her job was to watch height and range on her instruments, passing the range to the controller verbally and the height by instruments. Replying to the coroner, who suggested that the aircraft must have descended rapidly at some stage, Miss Maley said she did not recollect any rapid descent. When the Vulcan was about two miles away, it seemed to drop about 100ft below the glide-path and she mentioned this to the controller. She agreed that it must have recovered because later it was above the glide-path.

S/L. HOWARD was recalled and asked by the coroner whether it would be an abnormal rate of descent to drop 300ft in 500 yd. He replied that this would be "fantastic—about 4,000 feet per minute," and that he would have known if they had been going down at that rate.

W/C. C. K. SAXELBY, from the A. and A.E.E., Boscombe Down, said it had been found that, when the aircraft came close to the ground, the 70ft altimeter error could become about 130ft, added to which there was the 80ft for London Airport's height above sea level. It was quite possible for there to be a further error of 70ft caused by friction.

MR. B. M. STEPHENSON, representing the R.A.F., the M.T.C.A. and the two survivors, expressed his sympathy with the relatives of the deceased, and was joined in this by Sir David Scott Cairns and Mr. Eastham.

* * *

In a statement issued after the inquest, Mr. Stanley Mayne, secretary of the Institution of Professional Civil Servants, referred to one of the recommendations in Dr. A. G. Touch's report on the accident [*Flight* last week, p. 131], saying that a G.C.A. system in which the controller observes both sets of displays—thus eliminating the need for a tracker—had been developed and should be put into operational use as soon as possible. Similar equipment, said Mr. Mayne, had been in use in other countries for some years.

TAIL-END TV

Proposed Closed-circuit System for B-52 Tail-turret Control

THAT tail-gunners on Boeing B-52 bombers may soon spend their airborne hours watching a TV screen is not the latest result of U.S. telemania; it reflects a serious attempt to make life better, both physically and psychologically, for the man who has to sit for hours in lonely isolation, perhaps with an H bomb between himself and the other crew-members.

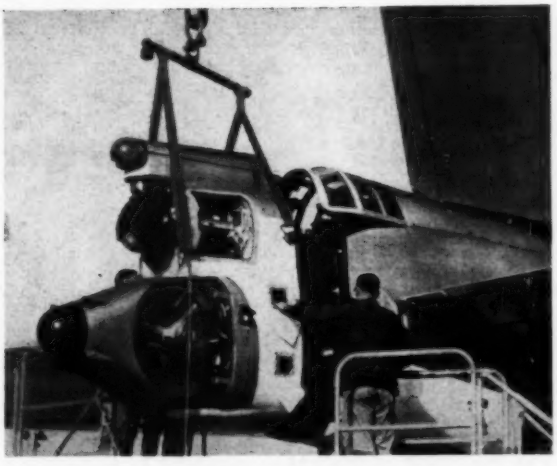
At present, the B-52 is fitted with the MD-9 fire-control system designed and manufactured by the Arma Division of the American Bosch Arma Corporation. In addition to a dual-unit radar sight for long-range search and short-range "lock-on" tracking, this has an optical sight which requires the presence of a gunner in the tail compartment. He does not lack "mod con.," for he has his own cooker, toilet and other facilities; but he can reach the main crew compartment (*via* a crawl-way) only when the aircraft is not pressurized.

In Arma's projected new AN/ASG-15 system, the gunner is re-positioned in the forward compartment, where he can enjoy the companionship of his colleagues without loss of efficiency, because the view he saw previously by direct vision will be brought to him by a closed-circuit television system.

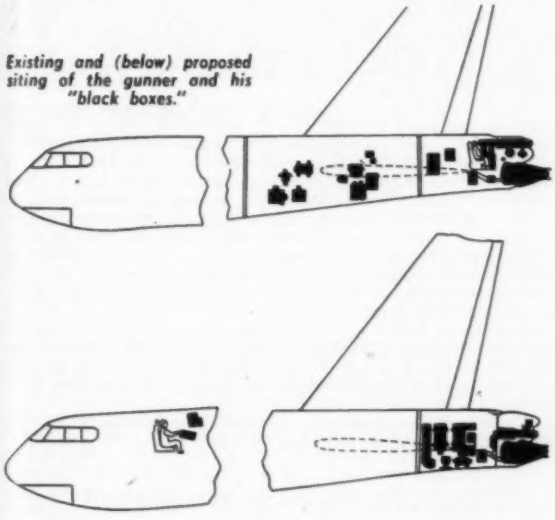
To ensure a full range of vision, the pre-production AN/ASG-15 system now under development uses two television cameras, one for track and search in the tail hemisphere and the other for extended search at lower altitudes. The second camera overlaps the coverage of the primary unit and even permits search and target-fixing directly beneath the aircraft.

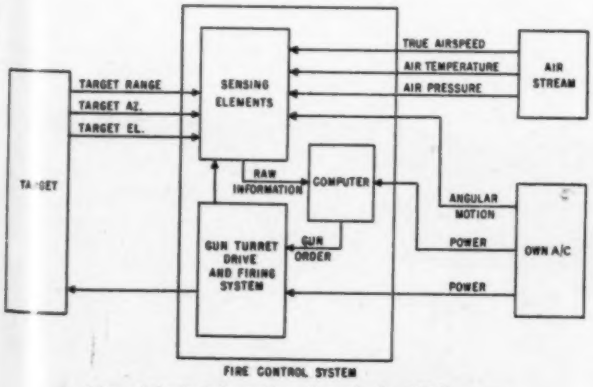
There is little fear of an enemy intercepter jumping the B-52 at night or in bad weather, because both the existing MD-9 and the new AN/ASG-15 provide full automatic radar detection and tracking at all times, at all operational heights and in all weathers. But the radar does not fire the guns automatically, as in a fighter's fire-control system, because it cannot distinguish friend from foe.

MD-9-controlled turret being installed as a unit in a B-52.

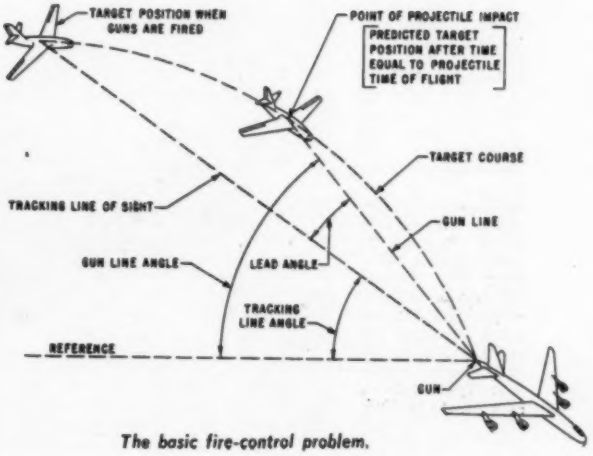


Existing and (below) proposed siting of the gunner and his "black boxes."





Flow of basic information through the MD-9 system.



The basic fire-control problem.

TAIL-END TV . . .

Instead, it signals to the gunner "target warning," "on target" and "fire," leaving him merely to squeeze the handgrip-trigger to complete the job. The tracking function is fulfilled by Monopulse radar, supplied by General Electric. This transmits two or four beams in simultaneous pulses and measures the phase and/or amplitude relationship between their various target-returns. It is ironic that this gave the Arma system a better performance than a competing G.E. system using conical-scan radar.

To achieve all this requires a complex collection of "black boxes" and equipment involving radar, electrical, pneumatic, hydraulic, optical, computing, control and gun-feed systems. The computer has to take into account the range of the target, range rate, angular positions, own speed, target's speed, air temperature, altitude, roll and pitch of own aircraft and trajectory characteristics—representing many more than a thousand changes of data every second—and use the resulting information to train the four 0.50in guns almost instantaneously with the proper lead to ensure that the target will be hit. Even so, Arma claim that "with the gunner and his gear, the weight of the MD-9 is comparably less than that of the manual defensive armament of either of the wartime B-17 or B-24 bombers."

Apart from what can be gleaned from the accompanying illustrations, no other details of either the old or the new systems have been released, except that angular motion is sensed and corrections made by gyroscopic devices. This was to be expected, as American Bosch Arma pioneered the production of gyroscopic reference systems for airborne, surface and underwater automatic fire control, and they are developing the all-important inertial guidance systems for the U.S. intercontinental ballistic missiles.

Proof of the effectiveness of the MD-9 has been given in practice shoots, in which it has been used in its automatic "radar mode" with great success against winged targets towed at jet fighter speeds. J.W.R.T.

A target shot up by MD-9 control operating in the fully automatic role.

ASYMMETRIC EMOTION

THE emotional relationship between a test pilot and his wife exercises a particular fascination for the film scriptwriter. Indeed, so great is the compulsion to highlight the feelings of the anxious wife (on celluloid there seem to be few other kinds) that films about flying can rarely avoid the temptation to exploit what must appear to be ready-made drama; and a good deal of powerful hysteria is churned out in the resultant process. The new film *The Man In The Sky* must be placed in this category; but to dismiss it as typical of "don't-go-in-the-air-Daddy" cinema would do less than justice to an unusually gripping and often authentic piece of filmcraft.

Made almost entirely at Wolverhampton Airport (background shots and streets are from the same locality) the film is concerned with one flight of a prototype freighter aircraft built by the small and struggling "Conway Aero Manufacturing Co. of Wolverhampton"—a firm whose size and ambitions form close parallels with at least two British manufacturers in business today. The freighter of the story is actually a Bristol 170 Mk 21, more accustomed to earning its living with Silver City Airways than as a film star: the irony of references to "our Bristol competitors" will not go overlooked.

The flight which forms the crux of the plot is undertaken in an endeavour to clinch a sale to a first—and hesitant—customer. A fault causes an engine fire which a feathered propeller and pressed fire-extinguisher button (accompanied by whirrs and hisses) are unable to extinguish. With violent wing-drop when speed is reduced, and with one engine inoperative, the pilot (Mr. Jack Hawkins) stays airborne until sufficient fuel has been consumed to attempt a high-speed landing in defiance of radio orders to bale out. And it is this situation that forms the back-drop to the film's climax. The sequence contains some *clichés* which are nevertheless well executed: the pilot's anguished vigil at the controls, punctuated by frequent lip-moistening and palm-wiping; the chief designer—conscious of his responsibility and the dangers of the open loading door—doodling airflow diagrams in the control tower; and the Conway employees deserting their benches one by one to gather and watch.

But the ability to create suspense (which should be a stock-in-trade of any good director) is very largely the ability to induce the audience to believe what they see—a process of self-identification. Some of the cockpit shots (which were filmed in a clever mock-up) were unrealistic in spite of the competent acting which supported them. The aileron cables, supposedly damaged in the fire, scrape through their conduits with a loud noise which echoes through the silent, empty fuselage; but why should engine noise be lacking? And can a vibrating structure echo? And the device of using loudspeaker-relayed R/T. conversation to relate the story both to the watchers and to the audience struck one as being rather crude—certainly it strained credulity.

It would be unfair to reveal the *dénouement* by describing the damaged freighter's landing. It may appear unduly hectic; but the film company is unlikely to forget the Bristol Freighter that was damaged at Wolverhampton while the sequence was being filmed.

Made by Ealing Studios for M.G.M., *The Man In The Sky* is scheduled for general release on February 18. A.T.P.

TO BE THE WORLD'S BIGGEST AEROPLANE: DOUGLAS'S 500,000 lb TURBOPROP C-132

"Flight" copyright drawing.

When, a year ago, the Long Beach division of Douglas rolled out their C-133 it seemed that the ultimate in "logistic" air transport had been reached. Yet the company's Tulsa division are well advanced with the far more impressive C-132. Powered by four 17,000 e.h.p. Pratt and Whitney T57 turboprops it will weigh 500,000 lb, will cruise at about 525 m.p.h. and carry 100 short tons of payload. First-flight date is expected to be 1959.

THE INDUSTRY

New Bristol Division

THE formation of a new Weston division of Bristol Aircraft, Ltd., incorporating the factories at Oldmixon and Banwell, was recently announced by the parent company, who state that the continuing expansion of work at Weston—as the two are jointly known—has made this reorganization necessary. Under it, Mr. W. Strachan becomes general manager of the Weston division, with direct responsibility to Mr. P. G. Masefield, managing director of Bristol Aircraft; Mr. R. Hafner as chief designer (helicopters) continues as the executive in charge of all technical and engineering aspects of rotary wing aircraft, remaining directly responsible to Dr. A. E. Russell, chief engineer; and Mr. R. S. Brown, works director of Bristol aircraft, will remain responsible to the managing director for all production policy throughout the Bristol Aircraft factories.

Mr. W. Strachan.

Bristol helicopter activities are now concentrated at Oldmixon; and at Banwell the company is engaged in the manufacture and development of rocket-motor tubes for guided missiles and research vehicles, in addition to a wide range of high-pressure gas-storage vessels for use in aircraft and guided weapons.

Mr. Strachan joined the Bristol Aeroplane Co. in 1925 as an apprentice, later becoming the company's representative at Martlesham Heath and Boscombe Down. During the war he organized the repair of Bristol aircraft in service with the R.A.F.; in 1942 he was appointed manager at Banwell (then building Beauforts and Beaufighters) and in 1943 visited the U.S.A. on behalf of the Ministry of Aircraft Production. As works manager of the Weston factories, Mr. Strachan in 1952 set up a rocket motor development unit which is now established at Banwell and was later responsible for organizing the new helicopter production centre at Oldmixon.

Aircraft Flowmeter Testing

CARRYING out his first public engagement since taking office, Mr. Aubrey Jones, the new Minister of Supply, on January 25 opened the fuel-flowmeter test house at the Rochester airport works of Elliott Brothers (London), Ltd., built ten years after the company established premises there and (in 1947) entered the aviation instrument field.

The test-house has been constructed for the calibration and testing of flowmeters being produced for Victors, Vulcans and Javelins; for the development of flowmeters for other military and for civil aircraft; and for research on flow-measuring systems.

It is a rectangular, brick-walled building with a flat concrete roof, surrounded by an area which is enclosed by wire fencing and is to be turfed. (The turf is to keep out dust and, in case of fire, to prevent burning fuel running along the ground.) Outside the building are two underground storage tanks of 750 gal capacity each.

The test-house is divided into several rooms, an outer one housing pumps, filters, Rotameters (themselves flowmeters of high accuracy) and associated equipment. This is sealed by a dividing wall from the observation room, where the four test-stands are, and entrance to which is *via* an air-lock. Other rooms in the test-house contain compressed-air supplies and refrigeration machinery, electrical services, workshop facilities and equipment for a Walter Kidde CO_2 fire-extinguishing system.

When a flowmeter transmitter is under test, fuel is drawn from the storage tanks by a pump with a capacity, at 30 lb/sq in delivery pressure, of 40,000 lb/hr. It passes through a Phillips wire-wound magnetic filter, filtering to a particle size of 5 microns, then *via* a shut-off cock to the flowmeter transmitter being tested. From there it flows, *via* a second shut-off cock, to a wide-ratio Rotameter with a capacity of 40,000 lb/hr and thence back to the storage tank through a set of throttling valves. A Fisher governor maintains the pressure at 30 lb/sq in, by-passing excess fuel to the storage tank. Tappings in the inlet and outlet pipes to the transmitter under test provide an indication of pressure drop on a mercury manometer.

Each test stand is equipped with a vibrator, to which is attached the transmitter under test, so that operational conditions can be simulated. The observer views his indicating instruments through double panels of armour-plate glass.

On the observer's right is a movable cabinet, containing electronic measuring equipment and slightly pressurized to exclude inflammable vapour. Services to the test stands include power at 26 volts 400 c.p.s. single-phase, 115 volts 400 c.p.s. three-phase, and 230 volts 50 c.p.s. single-phase; and also compressed air. By using suitable adaptors, sizes and capacities of flowmeter transmitter from 250 to 40,000 lb/hr can be tested.

At a luncheon after the opening ceremony, Mr. Jones paid tribute to the "remarkable progress" made by Elliott Brothers and described the new test-house as "a substantial contribution to the progress of flight."

Under test in the Elliott Brothers installation described on this page, a flowmeter can just be seen over the drip tray to the operator's left. Behind his head are Rotameters; to his right the electronics cabinet.

Avro Apprentices' Prizegiving

SPEAKING of the Vulcan at the A. V. Roe and Co., Ltd., annual apprentice prize day at Chadderton on January 18, Sir Roy Dobson, managing director, said it would probably be the last of the line of subsonic bombers and that "in the future we shall be entering realms that none of us know everything about."

At the Avro prize-giving: Sir Roy Dobson (managing director) presents the Freddie Bassett Trophy—a Vulcan model—to John McCuish. Looking on is Mr. H. Lomas, apprentice supervisor.

Among other awards, Sir Roy presented the Avro 504 Club Trophy to D. Brailsford as the best all-round apprentice and the Freddie Bassett Trophy (founded in memory of the A. V. Roe technician who lost his life in the Vulcan crash at London Airport) to J. McCuish.

Controlled-stretched Panels

INCREASINGLY wide adoption of integrally stiffened panels has brought with it a requirement for controlled stretching of the plates to relieve heat-treatment stresses before machining, thus reducing risk of distortion during the latter operation.

James Booth and Co., Ltd., announce that they are now manufacturing controlled-stretched Duralumin plates, previously available only from the United States, and that they have recently supplied a British aircraft constructor with a number of examples believed to be the biggest of their kind ever used in this country.

The largest of these plates—one of which is shown overleaf—measured 25ft 4in long, 2ft 8in wide and $1\frac{1}{16}$ in thick, and weighed 1,880 lb each.

The Birmingham firm state that such plates are manufactured by a process combining both forging and rolling operations, to ensure that in spite of their thickness they are uniform in mechanical properties and are not subject to the undesirable core effect to which material of this size is liable when produced solely by rolling. To ensure that the finished plates were free from

A large controlled-stretched plate (see page 189 and below) in the Birmingham works of James Booth and Co., Ltd. Though its destination is unstated, the dimensions quoted suggest that it is for a Vickers-Armstrongs Vanguard wing panel; milling of one of these panels on an Onsrud machine is illustrated in the current issue of our sister journal "Aircraft Production."

THE INDUSTRY . . .

internal defects they were examined by ultrasonic methods at both the ingot and finish stages.

Plates prepared in this manner conform variously to D.T.D. specifications 5010, 5020 and 5050. Though the size mentioned is believed to be the largest yet made in this country it is stated that plates up to 35ft in length can be supplied, though subject to a maximum cross-section of 65 sq in.

Blackburn Awards Presentation

WHEN the Vice-Chancellor of Hull University, Prof. Brynmor Jones, Ph.D., Sc.D., presented merit awards to apprentices of Blackburn and General Aircraft, Ltd., at the Guildhall, Kingston-upon-Hull, on January 28 he referred to the "three paths" of education—literary, scientific and technical. One alone was not satisfactory, Dr. Jones said; in each there should be something of the other two.

After the presentation of merit awards, Mr. Eric Turner, chairman and managing director of Blackburn and General Aircraft, presented the Robert Blackburn memorial prizes and also the

Mr. Eric Turner, Blackburn chairman, presents a £50 cheque—one of the Robert Blackburn Memorial Prizes—to apprentice M. Millard.

directors' prize (in the absence through indisposition of Mr. T. Bancroft, the works director).

The directors' prize, an inscribed wristlet watch awarded to the best all-round craft apprentice of the year, went to G. Langley; and M. Millard won both the £50 Robert Blackburn prize and a 15-guinea final year Higher National Diploma award.

Electro-Hydraulics Directors

APPOINTMENTS to the Board of Electro-Hydraulics, Ltd., and its subsidiary company, Conveyancer Fork Trucks, Ltd., have recently been announced. At the former, Mr. T. C. Wright has been appointed a director and works manager and Mr. A. Harold, A.F.R.Ae.S., formerly prototype manager and production engineer, has been appointed chief engineer.

Mr. C. B. V. Neilson, M.A., M.I.Mech.E., M.I.E.E., A.F.R.Ae.S., technical director of Electro-Hydraulics, Ltd.; Mr. R. Edwardes, A.C.W., A.C.W.A., secretary of Electro-Hydraulics, Ltd., and of Conveyancer Fork Trucks, Ltd.; and Mr. A. Harold have been appointed directors of Conveyancer Fork Trucks.

Preston Appointments

THE English Electric Co., Ltd., has announced three new appointments at its Preston works. These follow the expansion of aircraft activities there, resulting from the placing of a P.1 production order and continuing demand for the Canberra.

Mr. W. Harpley becomes aircraft manager responsible for all aircraft activities to Mr. W. Shorrock, M.B.E., manager of the Preston works; Mr. G. Walker becomes works manager (aircraft

Messrs. W. Harpley, G. Walker and R. Hothersall.

production) and Mr. R. Hothersall works manager (aircraft experimental). These appointments follow those announced recently of Mr. S. Maidment as chief production engineer (aircraft) and Mr. T. O. Williams as assistant manager (aircraft).

IN BRIEF

The appointment of Mr. Hugh Buckingham and Mr. P. C. Garratt as special directors has been announced by de Havilland Holdings, Ltd. Mr. Buckingham is a director, general manager and chief executive of the de Havilland Engine Co., Ltd. Mr. Garratt is chairman and managing director of the de Havilland Aircraft of Canada, Ltd.

* * *

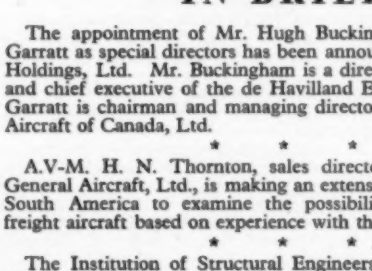
A.V-M. H. N. Thornton, sales director of Blackburn and General Aircraft, Ltd., is making an extensive tour of North and South America to examine the possibilities of future heavy freight aircraft based on experience with the Beverley.

* * *

The Institution of Structural Engineers, 11 Upper Belgrave Street, London, S.W.1, intend to make an award this year of one of the research scholarships offered triennially by the Aluminium Development Association. Its value is £600 p.a., it is tenable for a two-year period and entries close on March 31.

* * *

Scottish Aviation, Ltd., announce the formation of a new department to co-ordinate all aspects of sales, servicing and flight operations. Mr. N. J. Capper is appointed manager of this department; Mr. I. C. Reid, who for many years has been in charge of sales and service, becomes sales manager; and Mr. J. Logan is service manager.



Mr. W. A. Davis, works manager of Western Manufacturing (Reading), Ltd., since 1950, who has been appointed to the Board as works director. He joined the company in 1938 as chief planning engineer and, after the war, played an important part in the reorganization scheme put in hand in 1948.

CIVIL AVIATION

To the west: Prestwick at dawn is the scene of this dramatic photograph taken just prior to the Britannia 312's departure for Winnipeg on January 30.

BRITANNIA SOUTH

AT 1205 hr last Friday G-ANBI left London Airport on B.O.A.C.'s first scheduled Britannia 102 service for Johannesburg. A full complement—which included Mr. Basil Smallpeice, managing director of B.O.A.C., Sir Reginald Verdon Smith, chairman of the Bristol Aeroplane Company, and Sir Alec Coryton, chairman of the Bristol Engine Company—largely consisted of fare-paying passengers, not all of whom had expected to travel in the Britannia. The inaugural flight was a mixed-class service of 19 first-class and 48 tourist passengers, and a good crowd had assembled at London Airport to see the aircraft depart.

With previous postponements of the in-service date still fresh in the memory, many fingers were metaphorically crossed against an eleventh-hour snag. But last-minute difficulties—ironically enough of a personnel rather than a technical nature—did occur a few days before the first service was scheduled to begin. The Merchant Navy and Airline Officers' Association threatened drastic action over what they claimed were operationally unsatisfactory features of the Britannia cockpit, in which the flight engineer is a supernumerary crew-member. (An illustrated article on the Britannia cockpit appeared in *Flight* last week.) The Association further claimed that their threatened strike action was the culmination of earlier unheeded objections, and although postponement of the first scheduled service was averted by lengthy negotiation, the problem has yet to be resolved; a court of inquiry has been set up to investigate the dispute.

BRITANNIA WEST

AT 0634 G.M.T. on January 30, thirty days after its first flight, the Britannia 312 left Prestwick for Canada. It ably demonstrated its long-range characteristics by making the 3,750-mile polar route crossing non-stop to Winnipeg—overflying Iceland, Greenland and Labrador—in 11 hr 11 min chock to chock; the overhead-to-overhead crossing occupied 10 hr 52 min.

The aircraft—G-AOVA, the first Series 310—encountered tailwinds at the start of the flight and headwinds before arrival at Winnipeg, but it was reported on landing to have 3½ hours' reserve fuel remaining, which would have been adequate to continue the East to West crossing as far as Vancouver. The average airspeed was 366 m.p.h. and the cruising altitude—"in beautiful weather all the way"—was 30,000ft. That the flight was made while carrying the maximum payload of 28,000 lb (the crew numbered 45, but a considerable amount of equipment and baggage made up the weight) added lustre to the performance at a time when C.P.A.L. eyes are closely focused upon the long-range Britannias which they are to buy. Three of the airline's key technical personnel—Mr. Ian Gray, director of maintenance and engineering, Mr. Jack Parberry, operations engineer, and Mr. Eric McConachie, technical assistant to the vice-president of operations—left Canada recently to study for themselves modification progress of their 314s at Belfast.

In Canada meanwhile, Victor Able will undergo a series of intensive winterization trials—both airborne and on the ground—in co-operation with the Ministry of Supply, B.O.A.C. and the R.C.A.F. The tests will include landing on icy fields, low-temperature engine performance recordings, de-icing tests and general systems proving. At the completion of the trials, the aircraft is expected to make a trans-Pacific demonstration flight to Honolulu before returning to Filton near the end of the month.

To the south: An even more important Britannia departure last week was that of G-ANBI on the first scheduled service from London to Johannesburg. In this picture Captain F. A. Taylor and the first officer, Capt. H. L. Lee, head the crew lined up on the passenger steps.

WHAT COMES NEXT?

IN Parliament on January 30 the Minister of Transport and Civil Aviation, Mr. Harold Watkinson, made a statement which formally and finally terminated the short-lived de Havilland 118 project (see *Flight* last week). When the B.O.A.C. order for Boeing 707s was confirmed in October last year, it was simultaneously announced that B.O.A.C. and de Havilland were discussing a specification for an aircraft that could operate the North Atlantic non-stop as well as the Corporation's medium-haul Commonwealth and eastern routes.

The de Havilland company had, in fact, been studying the so-called "Comet 5" medium jet project for some while before they were asked by the Ministry of Supply to adapt it to North Atlantic requirements. Their conclusion was that it would be technically difficult—particularly in view of the time available if the aircraft was to be in service in 1962. Moreover, with the major airlines committed to Boeing 707s and Douglas DC-8s it was apparent (as we suggested on November 2 last) that a substantial world market for the aircraft might be hard to find.

Mr. Watkinson made also the first public announcement about the medium-jet projects which have been the subject of study by de Havilland, Bristol and Vickers. He said: "B.O.A.C. are accordingly discussing with de Havilland and a number of other companies alternative possibilities, including that of producing an aircraft not designed for non-stop transatlantic operation which may have more world-wide appeal." Although no

Another—larger—Fokker Friendship: In the hands of H. V. B. Burgerhout, this second prototype, PH-NVF, flew for the first time on January 29. This aircraft is fully equipped and is 3ft longer than the first Friendship.

CIVIL AVIATION . . .

mention was made of B.E.A.—whose medium jet interest stems from necessity rather than desire—the combined market offered by the Corporations would appear to offer at least the minimum business upon which a manufacturer would base export hopes.

Before such a project was finalized the following questions would require answering carefully: (1) Can a medium jet be produced which will show sufficient technical superiority over the DC-9 and Boeing 707-020 to attract airlines which—having bought big jets from those firms—will naturally be disposed towards their "junior" partners? (2) Do B.E.A. really require an entirely new type of jet for a limited operational requirement which could be met—admittedly less ideally—by the Comet 4A or a 4B? (3) What proportion of the 1,500-odd short/medium transports still required for the sixties will be jet, bearing in mind that the majority of orders are likely to go to transports with the lowest operating costs over the shorter stages? (4) If the market will absorb, say, 500 jet transports, is this sufficient business to warrant competing with the DC-9, Boeing 707-020, and the Convair 880? (5) If not, to what other commercial market should the industry turn to earn its living before the supersonic transport reaches the shop floors?

REVISED AIRWAYS

A RECENT M.T.C.A. Civil Aviation Information Circular (No. 8/1957) gives details of the new airways system for southern England and the stages by which the changes will be introduced. The plan was presented by the Minister of Transport and Civil Aviation last December, and a map of the new system appeared in *Flight* for December 28.

The first introductory phase takes place in April this year. The present Red Airway One (Chatham - North Foreland - Amsterdam) will be replaced by a new Red One (Brookmans Park - Clacton - Amsterdam) and a new Airway Blue "X" (Clacton - Brussels). Phase 2 should become effective between October and December; it involves the re-alignment of Green Airway One (Staplehurst - Coxyde) and Amber Airway Two. The new Blue Airway Three and Blue Airway "Y" will be introduced ("X" and "Y" are temporary identifications pending I.C.A.O. redesignation) and Blue Airway One will be withdrawn. The London Terminal Control Area and the London Control Zone will be also revised in shape at this time.

The final phase involves the introduction of the Gatwick Control Zone, the holding pattern at Crowborough and the introduction of Blue Airway One (Crowborough - Seaford); it should be completed in April 1958.

At the same time as the airways are revised, additional V.H.F. R/T channels will be introduced, existing channels will be amended and there will be changes in the radio navigational aids available.

NO GO ON NO-SHOW PLAN

IN *Flight* for October 5 we outlined the steps that the Air Traffic Conference (a branch of the U.S. Air Transport Association) was taking to try to overcome the perennial problem of the passenger who books a seat but fails to buy a ticket or to turn up at the aircraft. The Conference had at that time put into force a plan for a "last-time" by which a ticket must be collected if the reservation was not to be cancelled, and had proposed that, provided C.A.B. and 75 per cent of the airlines could agree, late cancellation charges and "no-show" penalities would be introduced as Phase II of the plan in February 1957.

But agreement between three-quarters of the U.S. domestic airlines—or anything like that amount—has not been forthcoming. At a meeting of the Air Traffic Conference two weeks ago the airlines failed to agree on the A.T.C. penalty system—which some thought too complicated and some still considered to be unnecessary. There is even some likelihood that the minimum time limit for collecting tickets—Phase I of the plan—will be rescinded, as the A.T.C. resolution of last June stated that if all the plan was not implemented by June 1, 1957, then both phases would be dropped.

In the meantime, a committee headed by Walter Sternberg, vice-president of National Airlines, is to study proposals put forward by National and Delta and will consider trying to combine "minimum time-limit" with the old "reconfirmation" rule (which requires that passengers reconfirm their intention to make use of their reserved seats).

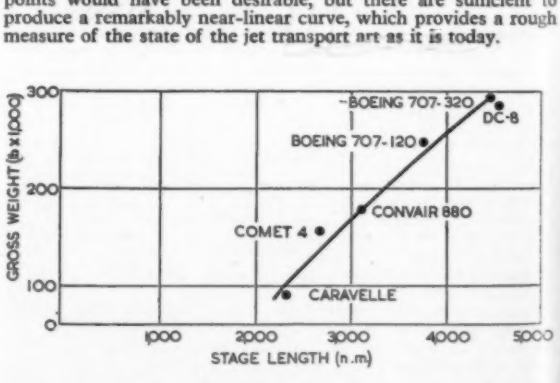
The National plan would retain the system of m.t.l. and provides that a passenger may reserve a seat up to three hours before scheduled departure, by (1) buying a *basic* ticket and by (2) purchasing a "pre-print" reservation charge ticket. Within three hours of departure, a passenger could buy only a basic ticket; if space was available it would be confirmed, or the passenger would be registered as a standby. The basic ticket would always be completely refunded, but the reservations charge ticket would generally not be refundable except at a predetermined time in advance of flight departure.

Delta accept penalties for late cancellations and no-shows but propose a different method to the A.T.C. plan. A passenger cancelling or changing a reservation by telephone in time to avoid penalties would be given a code number (distributed to the agent by A.T.C.) to write on his ticket. The agent could then check the ticket at leisure to determine the refund to which a passenger was entitled.

STATE OF THE JET ART

WHAT is the relationship between the size of a jet transport and its payload-range capabilities? Is it possible to establish some sort of datum from which to assess the performance of a given jet airliner? We reproduce below a graph, based on an illustration from the January 11 issue of *The Engineer*, which attempts to establish this gross weight versus stage-length relationship.

Compiled from data published in *Flight's* July 6, 1956, issue, the curve is a plot of the stage-length attainable by each of the new jet transports when carrying a payload equivalent to ten per cent of its gross weight. (This percentage represents a near approximation to the maximum payload of each type.) The distance over which this payload can be carried is of course dependent upon operating procedures and reserves, but *The Engineer* has plotted what appears—on the basis of the manufacturer's published performance—to be a reasonable and practical stage-length for each type. As the journal points out, more points would have been desirable, but there are sufficient to produce a remarkably near-linear curve, which provides a rough measure of the state of the jet transport art as it is today.



This curve shows the practical stage-length which might be expected for a jet transport when carrying a payload equal to one-tenth of the gross weight. The curve is based on the manufacturer's performance data for six known jet transports.

AIRPORTS AND THE TAXPAYER

THE report of the Select Committee on Estimates (reviewed in *Flight* last week) was recently the subject of further comment by Mr. Harold Watkinson, the Minister of Transport and Civil Aviation. Replying to the Committee's observation that it was "incomprehensible" that the Minister was not prepared to take more energetic measures to increase airport revenue, he said: "Our priorities must be safety and service in the operation of this country's airports. If providing these in full measure means that the operating costs of these airports cannot be for the moment completely recovered by the charges which they can make, then I remain completely unrepentant."

Mr. Watkinson was at pains to point out on another occasion that although the net operating costs of aerodromes under his control (the same figures were quoted in the report as operating losses) had risen in the past year to £1,856,000, the cost in 1951 had exceeded £2m. Over the past five years, therefore, the net operating costs were reduced by £150,000 although the number of passengers handled had risen from 2.5 million to 4.5 million in the same period. Turning to landing charges—the committee had recommended an increase—the Minister said that the problem was not one of airports alone; a unilateral landing-fee increase in Britain might injure the balance of payments and British interests generally. He was, he said, studying the report of the International Conference on Airport Charges and hoped to announce a scheme for increased landing fees "before long."

"OVER CONGESTED AREAS . . ."

AN amendment concerning low flying has been made to the Air Navigation Order 1954. The relevant section (rule 15, Schedule II) has been rephrased, and raises to "1,500ft above the highest object within 2,000ft of the aircraft" the minimum height for flying over what is now termed the "congested area of a city, town or settlement." But in order to comply with the further requirement that aircraft other than helicopters must be able, in the event of power failure, to "alight clear of the area without danger to persons or property," the rule adds a warning that it may be necessary for the aircraft to fly a good deal higher than 1,500ft.

Helicopters are a special case so far as altitude is concerned, and in only one prescribed area (the inner zone of London) are they required in an emergency to be able to land clear of the congested space; elsewhere—if they can do so without causing damage—they may land in the urban area.

BASE EXPANSION

TEN new hangar bays are to be incorporated in B.E.A.'s new engineering buildings at their London Airport base. When the new block is complete the buildings will be capable of accommodating the aircraft B.E.A. has on order—including the 20 Vanguards—as well as the existing fleets. The expansion (to which reference was made in *Flight*, January 4) has been made with the Vanguard in mind: the height of the new hangar will be ten feet greater than the present building and the depth 25ft more, and the total floor area of the hangars and workshops will be doubled. The new building—which will be complementary to the existing one—has been planned to provide (1) maximum utilization of floor area for production; (2) use of natural lighting wherever possible; (3) maximum flexibility of production space. More ground has been allocated for still further expansion if it is required.

DOUGLAS TURBOPROP

UNCONFIRMED reports in the U.S. magazine *American Aviation* say that Douglas are "almost certain" to bid for the short-haul market with a 40-44 passenger transport. The aircraft would be powered by four 1,500 h.p. turboprops—said closely to resemble earlier descriptions of the Lycoming T55—and would be generally similar to the Viscount, although the Douglas project is said to have "larger, more efficient engines," which is an obvious anomaly. The cruising speed is quoted as 320 kt and the aircraft should be capable of operating from a 2,500ft runway. With suggested delivery in 1961 at a price of less than £350,000, the report surmises that there would be an immediate potential market for 175 aircraft, excluding sales to foreign countries.

STAVERTON EXTENSION

AN article about Staverton airport in *Flight* last week explained the anxiety of the Gloucester and Cheltenham Corporations' Joint Aerodrome Committee to improve the airport's facilities by extending the east-west runway by 1,000ft to 4,120ft.

The project was brought a stage nearer fruition last week when the Gloucester City Council approved the runway proposal, and agreed to the provision of a cloud searchlight. The extension and improvement of the runway will cost, it is estimated, about £30,000; and another £3,500 may be allocated for the purchase of a radar approach aid. Cambrian Airways, who are Staverton's main users, will be asked to contribute towards this expenditure.

BREVITIES

BOEING has spent more than $2,250,000 of its own money on a thrust reverser and noise suppressor for installation on the 707 transport, it is reported in *American Aviation Daily*.

* * *

Jersey Airlines' last three D.H. Rapides will be withdrawn from service on April 14.

* * *

A North-East Airlines DC-6 crashed on Ricker's Island in New York's East river after taking off from La Guardia airport last Friday. Although some of the passengers and crew of 93 are missing, 60 people were saved.

* * *

A DC-7 and an F-89 Scorpion—both on test flights—were involved in a collision over the San Fernando Valley in California on January 31. The crew of four in the DC-7 were killed, but one of the crew of two in the Scorpion baled-out safely.

* * *

Aerolineas Argentinas have ordered ten F.27 Friendships for their inland services. The aircraft will be built by Fairchild.

* * *

Shannon Airport earned $2,100,000 in 1956, compared with $1,700,000 in 1955.

* * *

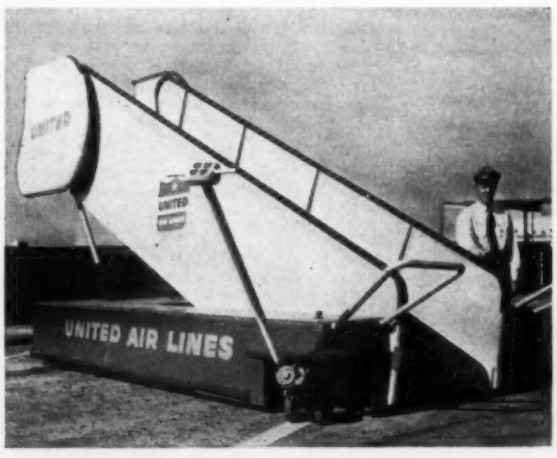
A civil aviation agreement has been signed by the Persian Foreign Minister and the U.S. Ambassador in Teheran with the purpose of increasing air traffic to and from the United States.

* * *

Aircraft of South African Airways are to be equipped with Smith S.E.P.2 autopilots. The company is the tenth overseas civil operator to place such an order.

A second Atlantic flight for Twinkletoes—sitting on the cockpit coaming—will be made in a Viscount on delivery to Capitol. He was Sir Arthur Whitten Brown's mascot in the Vickers Vimy in 1919.

United Air Lines have introduced this motorized passenger-loading stand at Los Angeles. It is shunted (at "nearly two m.p.h.") and raised or lowered by battery-operated 1 h.p. motors.



Mr. W. G. Burns, Dip. C.E., A.M.I.E.Aust., A.F.R.Ae.S. has taken up a three-year appointment at Australia House, London, as civil aviation liaison officer. He succeeds Mr. J. E. Schofield, who has returned to Australia on completion of his term of office.

CIVIL AVIATION . . .

East African Airways will start weekly services from Nairobi to Aden on February 13.

* * *

American Airlines have ordered Electra and Boeing 707 Erco flight simulators. They will be delivered in early 1958.

* * *

During the Paris Aero Show a helicopter service will be flown between the new Paris heliport at Issy-les-Moulineaux and Le Bourget. The frequency will be one departure every twenty minutes.

* * *

Linee Aeree Italiane have increased their Viscount order from six to ten. The additional aircraft will also be Viscount 770Ds. Viscount orders now total 361, and L.A.I. are the fourteenth customer to place a repeat order.

* * *

Ethiopian Airlines have purchased two DC-6Bs and taken an option on a third with credit obtained from the United States Export Import Bank. A total of 850 DC-6 and DC-7 aircraft has now been sold.

S.A.S. are reported to be negotiating with the Indonesian Government for a route to Djakarta by way of Bangkok or Tokyo.

* * *

The M.T.C.A. has awarded a contract worth £939,000 for the construction of the new terminal building at Gatwick Airport.

* * *

Captain Alfred Instone, J.P., chairman of Instone Air Transport, Ltd., has been made an officier de L'Ordre de la Couronne by His Majesty the King of the Belgians.

* * *

Sir Miles Thomas, former chairman of B.O.A.C., has been made a Commander of the Cedar of Lebanon by the Lebanese Ambassador.

* * *

Because of a demonstration tax of $15,000 in Canada, no demonstrations will be made there by the Twin Pioneer. It was to have been shown at Montreal and Ottawa.

* * *

An Armagnac on charter to Air France crashed in foggy weather when landing at Paris-Orly on January 29. One passenger of the 66 on board lost his life. The aircraft was on a flight from Tunis.

* * *

T.W.A. estimate that the four tubeless tyres fitted to their Super-G Constellations—which weigh *in toto* 50 lb less than tyres and tubes—will provide an additional $10,000 revenue annually on flights between London and Los Angeles.

* * *

Australian National Airways have been granted an import licence for the Djinn S.O.1221 helicopter. The same company is now using a new airborne electro-magnetic detector of copper and other minerals, built by its associate company Adastra-Hunting in Canada.

CLUB AND GLIDING NEWS

CHRISTCHURCH Aero Club, having begun the year with four Austers, five Tiger Moths and one Gemini, have now withdrawn two of the Tigers from use because of petrol rationing. Flying rates for the Austers (Gipsy-engined Alphas) and Tigers have now been set at £3 15s per hour, while the Gemini costs £7 15s per hour. At the side of the Christchurch clubhouse, another building has been erected to serve as an "air centre" for the five subsidized groups which fly with the Christchurch Aero Club. Further conversion of the club premises is planned. Last year's flying hours by the club, whose C.F.I. and manager are Bert Hawkins and T. H. Marshall, respectively, totalled over 2,600.

THE Canadian Owners and Pilots Association have made the first award of the A.O.P.A. Trophy, for significant contributions to Canadian civil aviation, to Keith Hopkinson, manager of Sky Harbor Air Services, Goderich, Ontario. The presentation of the trophy was made recently by J. B. Hartranft, Jr, president of the Aircraft Owners and Pilots Association (of the U.S.A.).

Mr. Hopkinson was selected for the award because of "his activity in promoting light aircraft in his area; his work in connection with obtaining repeal of the Ontario tax on aviation gasoline; his efforts to persuade Canadian authorities of the desirability of constructing landing strips adjacent to highways, and for his helpfulness to flyers generally."

RECENT committee changes at Elstree Flying Club include the election of Fred Beezley as chairman, in place of Bill Townend; and of Peter Laffy as secretary, in place of Paul Boucher. David Ogilvy and Peter Heywood remain as vice-chairman and treasurer respectively. Forthcoming events at Elstree include a Valentine party on February 16 and, it is hoped, the annual At Home during May or June.

THE Experimental Flying Group committee for 1957 consists of the following: J. Patey, chairman; W. Hearnden, secretary; D. B. Chubb, treasurer; R. H. Nicholls, chief flying instructor; and P. Elliott, engineer. The group's flying rates have been raised to £2 10s per hour. A total of 541 hours was flown during 1956.

FIRST member of the Kent Gliding Club to log a five-hour duration flight from Detling is Edward Day, who ridge-soared his Sky between Detling village and Blue Bell Hill on Sunday, January 27. One-week courses are being planned by the club for the summer; enquiries should be addressed to the secretary, Mrs. Joy Gardiner, 1 Devon Gardens, Birchington, Kent.

YORKSHIRE Aeroplane Club's flying total for 1956 amounted to 1,250 hours. Recent first soloists include Miss Peggy Stear, Messrs. P. Curtis, M. Woodhead, J. Appleyard, A. Burn-Jones, E. R. Walters, G. Askham, A. Oglesby, and cadets Thorpe, Willings, Legard and Bytheway.

INSTRUCTORS' courses are to be held at the Lasham Gliding Centre (by the B.G.A. No. 1 Instructors' School) from February 24 to March 9 and from March 24 to April 6. Cost will be £21 for each full 12-day period, or ten guineas for five days; these charges include accommodation, meals and all flying except aero-tows and retrieves.

A SERIES of nineteen one-week gliding courses has been announced by the London Gliding Club, Dunstable, for 1957. The number of pupils on each course, which begin on Monday morning and end the following Friday, is limited to twelve. The inclusive cost of each course is from £13 to £15, according to the date; an additional £1 is charged for weekend board and accommodation for those staying for two or three consecutive courses. The dates of the courses are given below; further details and application forms are available from R. Stafford Allen, London Gliding Club, Dunstable, Bedfordshire.

Dates of courses: April 8-12; April 29-May 3; May 6-10; 20-24, 27-31; June 17-21, 24-28; July 1-5, 8-12, 22-26; August 12-16, 19-23; September 2-6, 9-13, 23-27; October 7-11, 14-18, 21-25; October 28-November 1.

John Pothecary displays the 20-year-old Kronfeld Drone owned by Edward Gould at Christchurch. The machine has a Carden Ford engine.

Correspondence

The Editor of "Flight" is not necessarily in agreement with the views expressed by correspondents in these columns; the names and addresses of the writers, not for publication in detail, must in all cases accompany letters.

Disbandment and the R.N.V.R. Air Branch

CONTROVERSY over the disbanding of the week-end fliers has so far largely concerned the fighter squadrons—so that the arguments for the R.N.V.R. anti-submarine squadrons have hardly been heard.

It is not generally known that five squadrons of top-line efficiency in anti-submarine warfare were cut in the recent disbanding of the R.Aux.A.F. and R.N.V.R. Air Branch: two squadrons of Gannets, three of Avengers. The saving to the country totals about £2 million a year.

This minority of week-end fliers has probably even stronger ground than the fighters on which to dispute the case for their disbanding. Today the potential submarine threat to Britain is nine times greater than in 1939, when Germany started the war with 56 U-boats.

The R.N.V.R. squadrons are—or were until January 10—an integral part of that A/S defence pattern. Their skill and experience in the complicated A/S technique is the equal of regulars. Aircrews were at immediate readiness for emergency. Two squadrons operated Gannets, the most up-to-date A/S aircraft in the Navy, and better than any in the R.A.F. for the purpose—thus disproving the widely scouted notion that modern aircraft cannot be operated at maximum efficiency by week-end fliers.

What, then, can be the justification for disbanding them? It cannot be a question of efficiency; or it would be just as logical—or illogical—to throw away any of the regular existing A/S forces. It cannot be economy; for the R.N.V.R. squadrons are run at a fraction of the cost of those regular A/S forces.

It cannot be shortage of aircraft carriers; for these squadrons can equally well operate from land bases in an emergency. It cannot be that the personnel are growing too old, and that—with the stoppage of National Service flying training there will be no further replacements—because in A/S warfare experience counts, and the present squadrons as now constituted are good for at least another ten years. This would be time enough for a further review of their rôle, in the light of the development of weapons.

London, W.14. R. H. REDMAN.

The Short Seaplanes

READERS of the recent history of Short seaplanes in *Flight* may have been disappointed by the brief reference therein to the intriguing little Short S.364: as I said in the article, "singularly little information about the machine has survived." I have since been provided with some notes which are of value and interest.

The Short S.364 came within the Admiralty category N.2A, but was regarded as unsatisfactory because it was underpowered. The 200 h.p. Sunbeam engine with which it was fitted was "the predecessor of the 275 h.p. Sunbeam Maori"—which means, almost certainly, that it must have been the Afridi, a vee-twelve which had a bore of 92 mm and a stroke of 135 mm; the Maori was basically the same engine with the bore increased to 100 mm. The Short S.364 had an experimental wing section designed to Admiralty Specification B.I.R. 31; the initials signified Board of Invention and Research. The seaplane's bomb load consisted of only two 65-lb bombs.

The more assiduous historians will wish to note that the illustration of the S.364, which was from a photograph taken at the Isle of Grain experimental station, depicts the aircraft with floats of greater volume than those originally fitted.

The S.364's works number is something of a puzzle. As I said, the Short works numbers S.344-S.363 were allotted to the Short 320s which had the serial numbers N.1300-N.1319. However, of the later batch of 320s numbered N.1480-N.1504, it is known that N.1498 was S.382—which means that N.1480 must have been S.364. Was the works number S.364 inadvertently allotted to two different aircraft, perhaps because they were built in different factories? Is there any relevant significance in the facts that the (200 h.p.) S.364 bore the legend "Short Bros., Aeronautical Engineers, London and Sheppey," whereas the 320 N.1498 was marked "Short Bros. Aeronautical Engineers, Rochester, England"?

As a final point, can anyone confirm that the 225 h.p., 240 h.p. and 260 h.p. Sunbeams used in the Short 184 were respectively the Mohawk, Ghurka and Maori I?

Birmingham 32. J. M. BRUCE.

[Another Short 184 "find" is the picture below showing work in progress on a folded seaplane of this type. The original caption reads: "The war. Scenes with the French Army at Salonika. Tuning up. Photo shows: Lieut. Wright, who has performed excellent serial [*sic*] work at Salonika, preparing his biplane for an important observation flight." Suspecting the authenticity of this legend, we obtained from Major Maurice Wright, A.F.C., F.R.Ae.S. (a director of The Fairey Aviation Co., Ltd.), confirmation that the officer was, indeed, himself. The picture, he said, was taken in the shelter of Rabbit Island, off the Dardanelles, aboard the Monitor H.M.S. *Roberts*, from which he was doing gunnery spotting while on detached duty from H.M.S. *Ben-my-Chree*. "I managed to do an average of two spotting flights a day for about three months," writes Maj. Wright, "and, as you see, we had a considerable amount of work to do on maintenance to achieve this." He goes on to explain that he was spotting for the Royal Navy and was not working with the French Army. The firing took place at a range of about 15 miles; and sitting up over the Dardanelles for long periods required considerable physical effort, as the air was excessively turbulent. Maj. Wright used a primitive wireless set having a range of about 20 miles. Nevertheless, he describes the results as "quite good."

From Maj. Wright we obtained also the second photograph—an illuminating flashback to Mr. Bruce's series of articles on the F-boats (December 2, 16 and 23, 1955). It was taken at the Isle of Grain in 1917 and shows Maj. Wright (left), E. S. Goodwin and E. M. I. Bird, engineer officer. The aircraft is an F.2A with Rolls-Royce Eagle VIIs.]

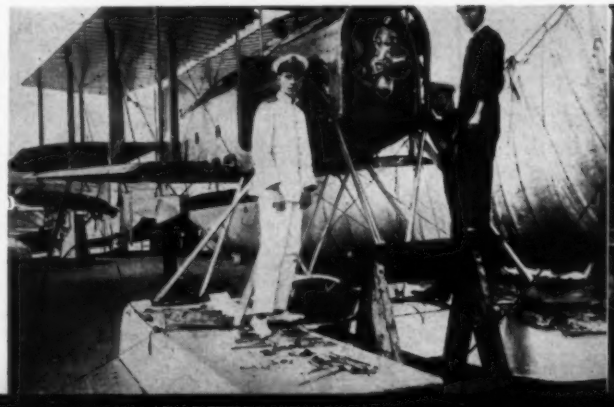
Gannets of the Channel Air Division, R.N.V.R.—a photograph provided by the writer of the first letter on this page.

Too Soon

YOUR issue of January 25 refers to a statement attributed to me in Johannesburg, to the effect that nuclear-powered civil aircraft would be flying between London and Johannesburg in ten to twelve years' time.

My statement in fact referred to turbine-powered supersonic aircraft. I should imagine that a nuclear powered civil aircraft would be later.

London, W.1. WHITNEY STRAIGHT.



The World War I snapshots referred to in the footnote to Mr. J. M. Bruce's letter. On the left is a Short 184 seaplane; on the right, an F.2A flying-boat.

Since forming at Nicosia last October, No. 284 Squadron (S/L. P. E. Fahy, D.F.C., A.F.C.) has played a vital rôle in round-up operations against Eoka terrorists. Seen here is a stream take-off by the Squadron's Bristol Sycamores.

SERVICE AVIATION

Royal Air Force and Fleet Air Arm News

No. 501 Sqn. Disbands

THE disbandment parade of No. 501 (County of Gloucester) Sqn., R.Aux.A.F., and No. 2501 (County of Gloucester) Field Sqn., R.Aux.A.F. Regt., was held at Filton airfield, Bristol, last Sunday.

H.R.H. the Duke of Gloucester, the squadron's Honorary Air Commodore since 1938, took the salute at the march-past and addressed the two units. He said that the reasons for disbandment had been given and must be respected, but he sympathized with the squadrons and knew that their fame would live on long after they had stood down.

He recalled that the Auxiliaries had joined the Regulars in the front line a few days before World War 2 began and that it was no mere chance that the first enemy aircraft destroyed in the conflict had fallen to Auxiliaries. They combined the traditional spirit of yeomanry units with great efficiency; and the Auxiliary squadrons had been an important source of potential commanding officers. The Duke also praised the ground crews for faithful service.

Recalling the history of No. 501 Sqn., he said its pilots had on one day in France shot down 18 aircraft before breakfast; they had destroyed the Heinkel He 111 which bombed Buckingham Palace; and, later had accounted for no fewer than 100 V-1 flying bombs at night. In November last year, No. 501 had been awarded its standard. The Duke also paid tribute to the sacrifices made by the families of Auxiliary personnel.

No. 2501 Sqn. had, he recalled, been formed in 1947 and he regretted that it had had so short a life. To both units the country owed a debt of gratitude; and he hoped that their voluntary service would not be lost to it. He himself was losing two squadrons and all their traditions and memories, and he wished them good luck and farewell.

Among many guests who watched the parade were Air Marshal Sir Thomas Pike, A.O.C-in-C. Fighter Command; A.V-M. V. S. Bowling, A.O.C. No. 11 Group, Fighter Command; Air Marshal Sir Douglas Macfadyen, A.O.C-in-C. Home Command; A.V-M. B. C. Yarde, Commandant General of the R.A.F. Regt.; A.V-M. J. M. Cohu, A.O.C. No. 61 Group; the Duke of Beaufort, Lord Lieutenant of Gloucestershire; and several former members of No. 501 Sqn.

Shortly before the parade took place it was learned that a No. 501 Sqn. pilot had lost his life in a Vampire he was reported to have been air-testing. The wreckage of the machine was found on the edge of the Avon Gorge, near the suspension bridge.

No. 602 Sqn. Disbandment

AT the final parade of No. 602 (City of Glasgow) Sqn., R.Aux.A.F., at R.N.A.S. Abbotsinch, Renfrew, on January 27, the Duke of Hamilton, its Honorary Air Commodore, said that the squadron's activities had been marked by great endeavour, enterprise and distinction in battle. The R.Aux.A.F. had in the past formed a bridge between the R.A.F. and the public which had been of incalculable value; and though, so far, there had been no official indication, he hoped that the bridge would be preserved in some manner. The Duke (who was presented with a model of a Vampire) was the fourth officer to join the squadron; and the parade warrant officer, W/O. H. J. Henderson, who had been with it for 25 years, was the Duke's air gunner in those early days.

Royal Visit A.D.C.

WHEN the Queen visits Portugal on February 16, Air Chief Marshal Sir George Mills will accompany her as senior Service officer. He is Commander, A.A.F.C.E., and was appointed an Air A.D.C. last month.

Esher Trophy

THE Esher Trophy for the R.Aux.A.F. fighter squadron judged to have the most efficient operational standards has been awarded for the second year running to No. 500 (County of Kent) Sqn., which is based at West Malling. Its Honorary Air Commodore is Sir Anthony Eden. Because of the impending disbandment there is some uncertainty as to whether the trophy will ever be officially presented.

1956 Boyd Trophy

THE premier annual award of the Fleet Air Arm, the Boyd Trophy, has been awarded to the crews of the two Whirlwinds which, together with an R.A.F. Sycamore crew, were responsible for the bold and skilful rescue of the 41 members of the crew of the s.s. *Dovrefjell*, which went aground on the Pentland Skerries last February.

The Whirlwind crew members were Lt. J. R. Palmer (now retired), Lt. R. H. Williams, C.P.O. A. Japp and P.O. Telegraphist R. Moneypenny.

Christmas Island Preparations

CANBERRAS of No. 76 Sqn. are now on a two weeks' training course in preparation for their part in the atomic weapon trials at Christmas Island. Many of the aircrew took part last year in atomic tests at Montebello and Maralinga. Their present training is being carried out in South Australia.

Sunderlands of the R.N.Z.A.F. at Laucala Bay, Suva, and Shackletons of No. 206 Sqn. from St. Eval, Cornwall, are to assist with weather reconnaissance and shipping patrols in the Christmas Island area. The latter unit has recently flown out *via* America.

Hastings of No. 24 (Commonwealth) Sqn. from Colerne have since last July been flying equipment, personnel and freight to Christmas Island from Honolulu, 1,200 miles away. On February 1 they also began a scheduled service to Australia. No. 1325 Flight, from Dishforth, are flying Dakotas on local communications flights.

To give accurate navigation and fixing coverage for the area a Decca Navigator Mobile Chain is to be used.

Squadron Ashtrays

SHOWN below is one of a series of ashtrays now available with R.A.F. squadron badges. Of nearly unbreakable toughened glass, and with the design ceramically burnt in so that it is proof against damage by lighted cigarettes or cleaning processes, the trays bear accurate representations of the badges in exact colours on a white background. Designs available include the R.A.F. *Per Ardua* crest, and badges for Nos. 1, 29, 34 and 43 Sqns., School of Air Navigation, R.A.F. Station Tangmere, and the Air Training Corps. In preparation are the badges of Nos. 25 and 41 Sqns. Priced at 5s 9d each, the ashtrays are made by Decoramics, Ltd., The Studios, 11b Liverpool Terrace, Worthing, Sussex, who also produce pint tankards, white tiles and other articles similarly decorated.

One of the ashtrays described above. It bears the badge of R.A.F. Station, Tangmere.